General Science Quarterly

Vol. VIII. NOVEMBER 1923 No. 1

The Technique and Value of Project Teaching in General Science

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CHAPTER II.

DESCRIPTION OF THE EXPERIMENT IN PROJECT TEACHING IN GENERAL SCIENCE.

1. DESCRIPTION OF PROJECT WORK IN GENERAL SCIENCE IN THE UNIVERSITY HIGH SCHOOL.

IN order to make a beginning in the determination of the extent to which project teaching can be justified, it was decided in the Spring of 1920 to organize the general science work in the University High School wholly on a project basis. This experiment was first attempted during the spring-summer term of 1920, with a class of 25 students. Mr. E. A. Muench was the teacher. The work was frankly tentative and experimental. It was a case of feeling the way to see if it was at all possible to carry on a class engaged in work upon general science projects.

Students were told that the class-room was to be a workshop, laboratory and study in which they could attack any of their own problems that fell within the field of general science. Materials and books were furnished for working out these problems. No attempt was made to organize these problems around a central theme. There was no predetermined sequence. Each student or group of students was to work upon the current "most immediate problem."

The following simple procedure was observed: (1) Each student or group of students decided upon a problem for work and study. (2) This decision was reported to the teacher and the teacher's approval secured before work was begun. (3) If the teacher did not approve, the student proposed an alternative. (4) The student made a plan, together with a list of

materials needed. (5) The student kept a running record upon 4x6 cards, giving his problem, the materials used, the books read, the time spent, and his own statement of what he had gained from the work.

The initial difficulty came in connection with carrying out the first of these regulations. When it was proposed to students that they be allowed to work upon their own problems some students immediately offered many suggestions and others had nothing to propose. In such a situation it was found necessary for the teacher to offer suggestions and in some cases to *assign* work. In order to avoid waste on the part of a few students, a sixth regulation was added to those presented above, to the effect that a student who did not propose a project would have a problem assigned him by the teacher. Clear distinction was made by the teacher between students' projects and such assigned problems. Record cards for projects and problems were kept separately.

This initial difficulty led to the first definite contribution from the experimental work, an accumulative list of actual students' projects as suggestive material for both students and teacher. If such a list had existed at the beginning of the experiment, many of the original difficulties might have been avoided.

Before beginning work in the Fall of 1920, a list was made from the card reports of all projects completed during the spring-summer term. All problems assigned by the teacher were discarded. This list of 150 projects formed the nucleus for the work done during the regular session of 1920-21. Mimeographed sections of this list were presented from time to time. Students were allowed to choose projects from these lists or propose new ones of their own. As new projects were completed, these were added to the original list. In this way, after a period of three years, the list of projects included in this study[35] was built up. New projects had, of course, to be approved by the teacher before work was started.

When a considerable list of workable projects had been accumulated, two needs presented themselves from the teacher's

35 See pp. 319-325.

point of view. One was some scheme for classifying and organizing the projects accumulated, and the other the determination of specific objectives which might possibly be reached by students engaged in project work in general science.

If the projects were organized around the usual topics found in general science texts, it was feared that the class work would tend to slip back into the topical teaching of subject-matter. The most natural organization of such material seemed to be upon the basis of the student activities involved in doing the various kinds of work. After a careful analysis of all the projects carried on during the spring-summer term of 1920, it was found that the following seven types of activity were involved:

1. Identifying things; finding out the names and characteristics of things.
2. Collecting.
3. Making and constructing things.
4. Taking things apart; analysis or dissection in the broader sense.
5. Observing, watching, looking on.
6. Trying to control the factors of one's environment.
7. Reading to secure information and answer queries.

Accordingly all projects were organized under these seven activities and the following group names adopted:

1. Identification Projects.
2. Collecting Projects.
3. Construction Projects.
4. Dissection Projects.
5. Observation Projects.
6. Control Projects.
7. Reading Projects.

All projects added since September 1, 1921, have been distributed according to this grouping. Obviously there was in some cases a question concerning the placing of certain projects. The classification of any particular project was determined by the kind of activity which predominated in carrying it out.

This classification furnished the basis for determining possible educational objectives to serve as helpful criteria for teachers in judging the worth of additional projects and to guide in determining the teacher's technique. The philosophical concept back of this determination of objectives was that the school exists for the purpose of helping boys and girls to better carry on the life activities for which they have imme-

diate need.[36] The list of projects gathered furnished sample activities within the realm of general science. The objectives were obtained by careful analysis of these activities. The principle of analysis was that of determining how students could be helped to better carry on such activities and others of a similar nature. This analysis resulted in the formulation of the following objectives for the guidance of teachers working with students engaged in project work in general science.

OBJECTIVES FOR PROJECT TEACHING IN GENERAL SCIENCE.

I. IDENTIFICATION PROJECTS.

1. To help boys and girls in becoming familiar with the names of things in their everyday physical environment.
2. To help boys and girls in becoming familiar with the appearance of things in their everyday physical environment.
3. To help boys and girls form associations between the names and appearances of things in their everyday physical environment.
4. To help boys and girls to become familiar with the usual location of things in their everyday physical environment.
5. To help boys and girls, through greater familiarity, to enjoy common birds, insects, wild flowers, trees, etc.
6. To help boys and girls answer such familiar questions as: "What bird is that?" What kind of weed is this?" "What is the name of that flower?"
7. To help students in learning to use keys and the commonly used identification helps.
8. To help students in securing control of biological and physical problems, such as eradication of weeds, deter mining what shrubs to plant, etc., through securing ability to identify the materials with which they work.
9. To help students to form habits of looking for the essential features of things.
10. To help boys and girls develop interests in trees, birds, plants, minerals, rocks, etc.

36 Cf. Dewey, "Democracy and Education," pp. 26-27, 47-48, Ch. V and VIII.

II. COLLECTION PROJECTS.

1. To help boys and girls in becoming more familiar with the plants, animals, minerals, etc., in their everyday environment.[37]
2. To help boys and girls develop interests in the plants and animals of their environment.
3. To furnish boys and girls with materials and information for developing wholesome and worth-while hobbies as a means of spending leisure time.
4. To help students in developing skill in properly organizing and classifying materials collected.
5. To help students develop skill in preparing and mounting specimens.
6. To help boys and girls develop habits of neat and accurate labeling of materials collected.
7. To help boys and girls in getting information concerning the materials needed for collecting and preparing specimens of animals, plants, minerals, etc.
8. To help boys and girls develop ideals of neat and orderly arrangement of materials collected.
9. To help students develop skill in the use of the equipment employed in collecting.
10. To help boys and girls develop skill in making equipment and preparations commonly used in collecting and preparing specimens.
11. To help students in forming the desire for getting additional information concerning the specimens collected.

III. CONSTRUCTION PROJECTS.

1. To help boys and girls make models of commonly used machines and physical apparatus.
2. To help boys and girls make better physical apparatus of the kinds which they ordinarily construct, such as

37 Obviously some types of student activity will lead towards the same educational objectives. These are repeated for each group.

pinhole cameras, motors, telephones, wireless outfits, water-wheels, etc.

3. To help boys and girls make biological equipment usable in the control of biological factors in their environment.
4. To help boys and girls find out how such things as soap, gas, gunpowder, mortar, cement, baking powder, etc., are made.
5. To help boys and girls in securing information about common biological, physical and chemical phenomena.
6. To help boys and girls develop wholesome and interesting ways of spending leisure time.
7. To help boys and girls develop skill in constructing apparatus needed for the control of their every-day physical environment.
8. To help boys and girls develop skill in repairing commonly used mechanical and electrical equipment.
9. To help boys and girls secure information needed in finding out what is wrong with mechanical and electrical equipment that fails to work.
10. To help students develop interests in commonly used mechanical and electrical apparatus.
11. To help students develop interests in the composition and behavior of common substances.
12. To help students in forming ideals of good workmanship.
13. To help students develop ideals of being satisfied only with the best that they can make, and of not being satisfied with the things which barely work.
14. To help students develop such habits of persistence that they will continue to work at a piece of apparatus until it does work and is well finished.
15. To help students in developing the problem-solving attitude.
16. To help students in developing habits of independence in working out the solutions to problems for themselves.

IV. DISSECTING PROJECTS.

1. To help students secure information about plants, animals, machines and substances in their daily environment.
2. To help boys and girls answer such questions as: "Of what is it made?" "How is it made?" "How does it work" etc.
3. To help boys and girls develop skill in taking apart and re-assembling machinery and commonly-used apparatus.
4. To help boys and girls develop skill in getting information about the structure of plants and animals.
5. To help boys and girls develop skill in securing information about commonly-used machines.
6. To help boys and girls spend leisure time more wholesomely and pleasurably by developing greater skill in "tinkering" with mechanical things.
7. To help boys and girls develop greater skill in determining the nature of common substances.
8. To help boys and girls in becoming familiar with available sources of information concerning the structure and composition of things in their daily environment, e. g., books, charts, diagrams, handbooks, etc.
9. To help students develop skill in the use of such available sources of information.
10. To help students develop habits of independence and initiative in securing information.
11. To help students see the need for great care in handling complex machines and complex biological organisms.

V. OBSERVATION PROJECTS.

1. To help boys and girls form habits of securing information by direct observation wherever possible, rather than being satisfied with dependence upon second-hand information.
2. To help boys and girls in securing information concerning their daily environment.

3. To help boys and girls form habits of looking for essentials when they are attempting to secure usable information concerning the biological and physical features of their environment.
4. To help students in becoming more systematic in carrying out observations.
5. To help boys and girls in forming habits of accurate observation of plants, animals, machines, etc.
6. To help boys and girls form habits of making accurate records of the things which they observe.
7. To help students in securing information useful in the control of the factors of their environment.
8. To help students in developing a scientific attitude towards facts and theories about plants, animals, phenomena, etc.
9. To help boys and girls form habits of making comparisons before drawing definite conclusions.
10. To help students form habits of seeking facts before drawing conclusions.

VI. Control Projects.

1. To help boys and girls develop the skill necessary to control the growth of some of the common plants in their environment.
2. To help boys and girls develop skill in controlling the growth and activities of some of the animals in their daily environment.
3. To help students develop skill in operating, managing and repairing some commonly used mechanical and electrical apparatus.
4. To help students in securing information necessary for the effective control of the biological and physical factors in their environment.
5. To help students see the need for co-operative control of the various factors in man's environment.
6. To help students develop independence in working out methods of control for themselves.

7. To help students develop skill in finding for themselves information needed for the control of biological and physical factors of the environment.
8. To help boys and girls in learning to work together for the control of those elements of their environment which require co-operative effort.

VII. READING AND INFORMATION PROJECTS.

1. To help boys and girls secure information that will answer their questions concerning natural phenomena.
2. To help boys and girls in understanding theories that have been worked out in the past to explain natural phenomena.
3. To help boys and girls in securing information needed for the control of the factors of their environment.
4. To help students in becoming better acquainted with the work of the world's great scientists.
5. To help boys and girls develop habits of reading science books, science magazines, and those parts of current periodicals devoted to scientific work and progress.
6. To help students in becoming familiar with the sources of information in the field of science.
7. To help students in developing skill in the use of the sources of scientific information.
8. To help students develop independence in judging the authenticity of statements concerning natural phenomena which they find in their reading.
9. To help boys and girls develop a worth-while means of spending leisure time by developing interests in reading science material.

Following is the list of projects which have been accumulated up to date:

I. IDENTIFICATION PROJECTS.	TENTATIVE VALUE
1. To learn to identify 20 fall-blooming wild flowers	10
2. To learn to identify 30 common weeds	10
3. To learn to recognize 15 fall-blooming garden flowers.....	3
4. To learn to recognize 20 native trees in their summer foliage	5

5. To learn to recognize 15 different butterflies 5
6. To learn to identify 15 different moths 5
7. To learn to recognize 20 native trees in their winter condition 5
8. To learn to identify 20 winter birds 10
9. To learn to identify 30 spring birds 15
10. To learn to identify 20 spring-blooming wild flowers...... 10
11. To learn to identify 20 common rocks and minerals...... 10
12. To learn to identify 15 shrubs used for ornamental planting 5
13. To learn to identify 20 destructive insects 10
14. To learn to recognize 20 kinds of automobiles 5
15. To learn to recognize 10 insects useful to man 5
16. To learn to recognize 20 plants used for field crops...... 5

II. COLLECTION PROJECTS.

1. To collect and mount with labels 20 different kinds of butterflies 10
2. To collect, mount and classify 20 different moths........ 10
3. To collect, mount and classify 40 different kinds of insects 15
5. To collect and label 25 kinds of weed seeds 10
4. To collect and mount 20 different common weeds....... 10
6. To make a wild flower collection 10
7. To collect and classify 20 common minerals 10
8. To collect and mount 20 kinds of wood and label with names and uses 10
9. To make a collection of 30 kinds of wild flowers and plant them in a flower garden 15
10. To collect 10 kinds of water animals for the school aquarium 2
11. To make a collection of 10 kinds of carbon 1
12. To collect 15 fall flowers, 10 composite and 5 simple...... 5
13. To collect, classify and label 25 kinds of fruits.......... 5
14. To collect 10 garden pests and label them with names and means of combating them 5
15. To collect 5 pounds of dandelion or burdock roots and prepare them for market 10

III. CONSTRUCTION PROJECTS.

1. To make a rag doll seed tester and test seeds for spring planting 2
2. To make a seed corn tester 3
3. To construct a hot bed and grow early plants for the garden 10
4. To make a box trap. To study fur bearing animals, their habitat, homes, life, uses of fur and its quality....
5. To make a rabbit hutch that will be fitted for raising domestic rabbits in the back yard 5
6. To make a balanced aquarium 2
7. To make four types of bird houses and place them in suitable places for attracting birds 5
8. To make a vivarium for studying insects 2
9. To make an ant cage and observe the activities of ants ... 3
10. To make an insect net for use in insect collecting 1
11. To build a fly trap and help get rid of flies 3

12. To make a water turbine 2
13. To make a Dutch windmill 1
14. To make a pony brake and test horse power 3
15. To distill water 1
16. To make a siphon and learn how it works 1
17. To make a barometer 2
18. To construct a lift pump and find out how it works 2
19. To make a force pump 2
20. To construct a model hot water heating system 2
21. To make a periscope and find out how it works 3
22. To make a thermometer 2
23. To make a camera for copying drawings 5
24. To make a pin hole camera 5
25. To make a projection lantern 5
26. To make a string telephone 1
27. To make a broomstick xylophone 2
28. To make a push button 1
29. To make a knife switch 1
30. To make an electro-magnet 2
31. To make a buzzer 2
32. To make an electric bell 2
33. To make a burglar alarm 2
34. To make a voltaic cell 1
35. To make wet cells out of old dry cells and operate an electric bell with them 1
36. To make an ammonium chloride battery 1
37. To make a copper plating apparatus 1
38. To make a current detector 1
39. To make a wire coil rheostat 5
40. To make an induction coil 5
41. To make a telegraph instrument 2
42. To make a miniature lighting system including wiring, switches, etc. and operate the lights with the school dynamo 5
43. To build a motor 15
44. To make a wireless outfit 20
45. To make a Dutch doll barometer 1
46. To set up and operate a telephone line 2
47. To make soap 1
48. To develop and print 12 pictures 2
49. To make an acid from wood 2
50. To make a chemical garden 2
51. To make acetylene gas 2
52. To make phosphine smoke rings 2
53. To make gun powder 1
54. To make coal tar and coke 2
55. To make colored fire 2
56 To make mortar 1
57. To make cement 2
58. To make ice 2
59. To make disappearing ink ..... ½
60. To make 10 blue prints 2
61. To prepare carbon dioxide and find a test for carbon dioxide 1
62. To prepare oxygen 1
63. To make coal tar and coke 2

IV. DISSECTION PROJECTS.

1. To cut up 5 kinds of seeds and find out of what they are composed 2
2. To make apart 5 kinds of flowers, learn the names of the parts and find out the uses of each part 2
3. To take a clock apart, find out how it works and put it together 1
4. To take an electric bell, apart, find out how it works and put it together 1
5. To tear up an old dry cell and find out how it is constructed 1
6. To take a small steam engine apart and find out how it is constructed 2
7. To tear up an old spark coil, find out how it works and put it together 2
8. To take an old camera apart, find out how it works and put it together 2
9. To take a dissectible dynamo apart, find out the purpose of each part and reassemble the parts 2
10. To take an old gas engine apart, find out how it works and put it together 5
11. To find out what water is composed of 1
12. To empty a fire extinguisher and recharge it 1
13. To find out what elements there are in milk 1
14. To find out what food elements are present in 10 common foods 5
15. To find out what food elements are in wheat flour 1
16. To find out what fibers are used in 10 samples of cloth ... 5

V. OBSERVATION PROJECTS.

1. To determine by observation the factors governing the germination of seeds and the growth of plants 10
2. To observe how environment,—light, darkness, temperature and different soil types,—affects the growth of plants 10
3. To find out by observation in the field how plants are carried from place to place 2
4. To observe how insects help in the pollination of flowers .. 1
5. To find out how many plants may be produced by a single weed plant 2
6. To find out how many kinds of weeds grow on a vacant lot by making a weed survey of the lot 5
7. To find out how new plants are produced by a visit to observe the work carried on in a green house or nursery . 1
8. To determine by observation the factors influencing the growth of bacteria, yeasts and molds 5
9. To find out what happens during fermentation by watching yeast cultures that are growing 2
10. To find out how many kinds of bacteria are present in a freshly swept room 2
11. To determine if bacteria are present in drinking water .. 2
12. To study and report upon the habits and activities of the animals in the vivarium or pet pens 3
13. To observe and report upon the activities of the water animals in the aquarium 3

14. To find out how squirrels behave by watching squirrels in parks, home grounds or woods 3
15. To watch the flow of blood in the veins of the web of a frog's foot 1
16. To observe the behavior of one-celled animals under the microscope 1
17. To find out by observation what 10 different kinds of birds eat 10
18. To find out how birds care for their young 5
19. To find out by observation how 5 birds construct their nests 10
20. To find out how much toads help the gardener 2
21. To find out how frogs develop by watching the development of frogs eggs and tadpoles in a battery jar aquarium 5
22. To study and report upon the habits and activities of ants 3
23. To learn how moths and butterflies develop by observing the eggs, larvae, pupae and adults in the field and in cages 3
24. To watch the development and activities of bees 3
25. To find out how house flies spread disease by observing the activities of flies 3
26. To find out how motion pictures work by observing a motion picture machine in operation 2
27. To find out how mosquitoes develop by observing the development of an egg raft in a tumbler of water 3
28. To find out how a steam engine works by watching an engine in operation 1
29. To find out how a gas engine works by watching one in operation 2
30. To find out how gas is made by a visit to the gas plant 1
31. To find out how a hot air furnace works by examining one in a house 1
32. To find out how a hot water heating plant works by observing a system in operation 1
33. To find out how a barometer behaves under varying weather conditions 2
34. To find out how the weather bureau predicts the weather by a visit to the local weather station 1
35. To find out how a block and tackle works by watching one in operation 1
36. To find out how scales and balances work by watching them in operation 1
37. To find out how sound is transmitted by observing the behavior of a number of sounding bodies 2
38. To find out how artificial ice is made by a visit to the local ice plant 1
39. To find out how magnets work by observing them under different conditions 1
40. To find out how pumps work by observing pumps in operation 1
41. To find out how electric power is produced by a visit to a local power plant 1
42. To find out how the local water supply is distributed by a visit to the water plant 1
43. To find out the conditions necessary for good ventilation 1

44. To keep for two weeks a daily record of the readings of a water, gas or light meter 2
45. To find out how the streams affect the surface of the land by a visit to a neighboring stream 2

VI. CONTROL PROJECTS.

1. To care for the ornamental plants in the school building for one month 5
2. To establish and care for wild flower garden 10
3. To make and keep a flower garden at home or at school . 20
4. To grow 12 ornamental house plants from seed 5
5. To grow 12 ornamental house plants from cuttings 5
6. To get rid of all the weeds in the lawn at home 10
7. To plant and care for a vegetable garden 25
8. To find effective means for checking the growth of common bacteria, yeasts and molds and to learn to use these means 10
9. To innoculate legumes with nitrogen collecting bacteria 3
10. To make diets for reducing 5
11. To make diets for thin boys and girls and to keep a record of the gains made by the use of these diets 5
12. To learn to eat the best foods for growth 5
13. To care for the pets belonging to the school for one month 5
14. To care for the school aquarium for one month 5
15. To get rid of all the mice in the school building 5
16. To get rid of all the mice at home 5
17. To get rid of all the sparrows about the home 5
18. To attract as many birds as possible to the home 10
19. To establish a bird feeding ground for winter birds 5
20. To establish a bird refuge 10
21. To keep a flock of hens and keep an egg record 20
22. To care for a pair of rabbits for the winter 10
23. To hatch and raise 12 chickens 20
24. To learn to destroy insect pests and to destroy such pests in the home garden 10
25. To get rid of all the flies at home 10
26. To get rid of all the mosquitoes in the neighborhood ....
27. To carry on a fly campaign in the neighborhood ....
28. To set up an electric telegraph, learn the Morse code and learn to send and receive messages 10
29. To learn to operate a steam engine 5
30. To learn to operate a gas engine 5
31. To learn to use a compound microscope 2
32. To learn to use a barometer 2
33. To learn to read electric, gas and water meters 2
34. To learn to set up and operate a block and tackle 1
35. To learn how to operate and repair a vacuum cleaner 2
36. To learn to operate and care for a pressure cooker 2
37. To learn to operate and care for a talking machine 3
38. To test the dry cells in the laboratory 1
39. To learn to repair fuse plugs 1

VII. READING AND INFORMATION PROJECTS.

1. To learn the steps in the evolution of the higher forms of plant life 5

2.	To find out how new varieties of plants are produced by natural and artificial means	5
3.	To find out how food is digested and absorbed	3
4.	To find out the effect of different kinds of clothing on the body	3
5.	To find out how the blood circulates in the body	3
6.	To find out how we breathe	3
7.	To find out what is meant by evolution and to learn the steps in the evolution of the higher forms of animal life	5
8.	To find out how new varieties of animals are produced by natural and artificial means	5
9.	To find out the causes of 10 common preventable diseases	10
10.	To find out the best ways to fight flies	2
11.	To find out how salt helps in freezing	1
12.	To find out why a lift pump will not raise water more than about thirty feet	1
13.	To find out how musical sounds are produced	3
14.	To find out how sound is transmitted	3
15.	To find out how light waves travel	3
16.	To find out why a camera will take pictures	2
17.	To find out why a dynamo will produce an electric current	3
18.	To find out why a motor will turn when an electric current is sent through the armature	3
19.	To find out what keeps an aeroplane up	2
20.	To find out why a steel ship floats	1
21.	To find out what makes magnets attract iron	1
22.	To find out the cause of rain	3
23.	To find out the cause of thunder and lightning	1
24.	To find out what is meant by chemical elements	2
25.	To find of what air is composed	1
26.	To find out what 10 great scientists have accomplished	10
27.	To find out how Mendel's law works	3

Using the cumulative list of projects just presented the experimental class in general science was continued during the regular sessions of 1920-21, 1921-22 and 1922-23. An idea of the type of work carried on during these years can best be secured by reference to the following directions which were typed and posted on the bulletin board for the guidance of students.

DIRECTIONS FOR CARRYING ON GENERAL SCIENCE PROJECTS

1. Students may choose their own projects for work with the advice and consent of the teacher in charge.
2. Students who do not choose projects will be assigned problems by the teacher.
3. Problems and projects must be finished before the students working upon them receive any credit.

4. Each student is expected to do some reading to help in the understanding of his work.
5. Students must make a record of each problem or project attempted. Reports are to be made on 4 x 6 cards. Each card is to show the name of the student in the upper left hand corner, last name first, the date of the beginning of the project in the upper right hand corner, the number of hours required to finish the work, the books read while at work, and a statement of results or a statement of what has been learned.
6. Reports must be properly made before credit for any project can be received.
7. Students who are not otherwise engaged will be expected to occupy themselves in cleaning and caring for equipment, keeping the room in order, or in reading books from the science library.
8. Supplies are to be drawn from the teacher or storekeeper. No student is expected to enter the storeroom except at the request of the teacher.

In order to check and evaluate more definitely the work of individual students a point system for evoluating work was developed. Again, the card reports of projects actually completed by students furnished a working basis. The chief factor considered was that of relative difficulty as determined by the amount of time needed to successfully complete a project. Two hours were taken as the unit, since class periods were double periods, two hours in length. Thus a project requiring six hours to complete would, other things being equal, be assigned a value of three points. In order to avoid the undue extension of projects the point values were assigned by the teacher and appeared to the students as arbitrary standards of value. As projects were repeated by various students corrections were made in the values assigned. Other qualitative corrections were arbitrarily made by the teacher and science supervisor to adjust obvious differences in the social values of some projects. Point values assigned to projects, are, therefore, to a large extent empirical and merely relative, not in any sense absolute.

As point values were determined they were incorporated on the project list. When suggestive lists of projects were presented to students point values were also presented but not emphasized. The values used in the experimental classes accompany the list of projects presented above. It should be clearly understood in this connection that this point scheme was used merely as a piece of administrative machinery to facilitate the handling of project work by the teacher.[38] Care was used to avoid emphasizing the number of points to be secured by a piece of work in order that a student might not work merely for points. The directions observed by teachers in determining and administering point values were as follows:

1. Each student must complete a minimum of 90 units of work during the term. Superior grades will be assigned for a total of more than 90 points of work *well done.*
2. Values shall be assigned to projects upon the basis of two hours work for each unit. The teacher is to be the judge in determining if time is well spent.
3. No student shall receive credit for a project until the project is satisfactorily completed, the record of the project completed and both approved by the teacher.
4. Completing a project shall include reading sufficient reference material to enable the student to understand the work done.
5. Students may receive credit for reading science books other than those read in connection with projects. A list of books with the units for reading them will be kept posted on the bulletin board.
6. One unit will be given for each report of work done to the class.
7. A list of projects with the credit for each will be kept posted on the bulletin board in the science room.

2. The Teacher's Technique in Project Teaching in General Science.

One of the first problems raised by practical school people when project teaching is proposed is that of how to carry out such work under present school conditions. What are teachers to do while students are at work upon projects? How can the work be managed and directed? How can the teacher guide the student in the selection of his projects? If students in the same class do not all carry on the same work at the same time how can they be managed by the teacher? These questions

38 Sanders, "A System for Checking up Individual Projects in Biology." Sch. Sc. and Math. 19, pp. 329-333.

all came up in connection with the attempt to carry on the work described in the preceding section. In the attempt to solve these problems for the general science teachers in the University High School the following series of directions for teachers were developed:

A. Management of Class Routine

1. Have the whole group assemble for roll call.
2. Go over the day's work quickly with the whole group to be sure that each student knows clearly what he is going to do.
3. Hold all students who do not have definite projects.
4. Insist that students who know what to do begin work promptly.
5. Go over their work with students who are not ready to begin.
6. See that records are begun with the projects and are kept up to date rather than "written up" afer the projects are finished.
7. See that reports are filed in alphabetical order in the file provided for that purpose.
8. Allow sufficient time at the end of the class period for *students* to get books and apparatus in place and leave the room in good order.
9. Have the group assemble at the end of the hour and dismiss all at once.

B. Selection of New Projects

1. Hold a group conference with the people who are in need of new projects.
2. Distribute to this group typed or mimeographed sheets of suggestive projects.
3. Go over this list of projects with the group. Describe briefly what the doing of each project might involve, and the value of doing such a piece of work. Encourage students to ask questions.
4. Have students, after writing their names on the suggestion sheets, check the project or projects which they wish to carry out.

5. Have students who do not check any of the projects suggested write out their own proposals at the bottom of the suggestion sheet.
6. Collect the suggestion sheets and give to each student a direction sheet for the project he has selected.
7. Assign problems to students who neither select projects from the suggestion sheet nor propose others, and distribute direction sheets for such projects.

C. MANAGEMENT OF PROJECT WORK.

1. Direction sheets should give general directions to guide students in doing their work. Usually the order of work should be suggested, together with a few references for reading. As much planning as possible should be left to the students.
2. Students who have proposed new projects should begin planning their work on paper as soon as their projects have been approved by the teacher. They should not begin work until their plans have been approved.
3. Books, diagrams, models, pictures, etc., that will help students in their work should be made readily available upon a central table.
4. Students should be required to write out neatly a list of materials, tools and apparatus needed, in so far as they are able to determine, and have this list approved by the teacher before beginning work.
5. Each student should present such a list to the storekeeper when drawing supplies.
6. Each student should be required to begin a record of each project when he begins working upon that project, and keep the record up to date.
7. Projects may be carried on by individuals, by small groups, or by the class as a whole. If a project be a class project a large majority of the class should agree upon its value. Small group projects should be carried out by homogeneous groups. The teacher should, however, be quick to break up groups which do not work profitably together.

8. Most of the work can be directed by means of individual and small group conferences, while the class as a whole is at work. General class discussions need not take place every day. Recitations, as such, should be avoided.
9. When students have finished projects, a report of the work done should often be made to the whole class. Such reports may frequently be accompanied by demonstrations, diagrams, drawings, etc. Other members of the class should be encouraged to ask questions of those making reports.
10. Reports to the class need not be made for every project. Each member of the class should, however, have the opportunity to make some reports.

D. CHECKING THE QUALITY OF PROJECT WORK.

1. Each completed project and the record of the project must be approved by the teacher.
2. When a student's work has been approved the student should be credited with the number of points allowed for the project when completed.
3. The teacher should use care in seeing that students thoroughly understand the principles underlying the work that they are doing.
4. Work that is not the best that a student is capable of doing should not be approved, and a student should not receive credit for such work.
5. Quizzes and examinations are not necessary. The student's product, his record of the work, his reports to the class, and the teacher's observation of his work, furnish sufficient evidence both as to the quantity and quality of work.

E. MANAGEMENT OF STUDENTS.

1. See that each student has a definite place to work. Students should take these places at the beginning of the class period.
2. Insist that students "stay put." Permit all necessary freedom but curtail aimless wandering from place to place.
3. See that students are not allowed to enter the storeroom to select equipment for themselves.

F. HANDLING EQUIPMENT.

1. To facilitate the use of equipment, teachers will find it convenient each day to set out on the tables in the store-room the equipment to be used next day. If work is properly organized there should be time to do this during the regular class period.
2. All equipment should be returned to the shelves clean and in order as soon as used. The student store-keeper may do this if properly supervised. Apparatus should be taken down and cleaned by the students who have used it.
3. Science books should be kept in order at all times. A student librarian may be selected to care for books.
4. Science books should not be issued to students for out-of-school use. Books should be read and studied during the class period.
5. All scraps of paper, broken glass, and other waste should be placed in the waste basket or tub *by the students.*
6. Teachers should close class work in time for *students* to clean apparatus, put away books, and leave the room in good order for the next class.
7. Each teacher should endeavor to systematize the handling of books and apparatus in such a way as to economize time and secure a maximum use from the equipment.

G. MANAGEMENT OF FIELD TRIPS.

1. Field trips are profitable if made for the purpose of attaining some definite objective. Unorganized field trips are usually profitless. Without a definite purpose students are apt to look upon such trips as larks, or merely as excuses for outings and relief from routine work. Under such circumstances students are apt to be difficult to manage, are apt to stray, and make it difficult for the teacher to be of any assistance to the group.
2. Field trips are often desirable, but should be taken only when the need for such work grows out of the problem in hand. Field trips may possibly be the first thing to be undertaken in working out a new project. In such cases, however, the above rule still holds.

3. Field trips may be of two kinds, class excursions directed and controlled by the teacher, and more or less independent excursions by individuals or small groups.
4. Field trips may be made for securing information, e. g. a visit to the ice plant, a visit to a typical ravine, or an electric light plant; for purposes of observation, e. g. to watch an ant's nest, to make observations of bird habits, or to see how an engine works; and for gathering materials and making collections.
5. The teacher should have clearly defined the purpose for the trip and have estimated the value of the trip to the students.
6. The teacher must know the territory to be covered.
7. For class excursions the teacher should go over the ground before the class. He should secure necessary permissions and thoroughly plan the work to be accomplished. He should note things to be observed in going over the ground. He should see that all necessary equipment is provided before time for the excursion.
8. The object of the trip should be made clear to the students. The class should have the attitude of accomplishing definite results. Students should be made to feel responsible for accomplishing results as if they were at work in the class-room or laboratory.
9. Each individual in the class should be made responsible for something: recorded observations, material collected, etc. A good device to this end is to make each student responsible for some field equipment.
10. It should be clearly understood by the members of the class that they are to stay together and are to be prompt in forming a group for getting suggestions from the teacher.
11. The teacher should know how long a trip will take to complete and insist upon starting to return in time.

If a closer organization of projects than the organization presented in the preceding section seems desirable to enable the teacher to plan work somewhat more definitly and to prevent possible scattering of the teacher's energies, two kinds of

groupings are possible. One is seasonal organization, that is putting all projects that can best be done in September and October in one group and those that can best be done in November and December in another, and so on. Another possible type of grouping is that of arranging a number of projects around one large central project, such as food, air, transportation, etc.

Following are samples of these two types of internal organization of projects:

A. SEASONAL ORGANIZATION.

September-October Projects.

IDENTIFICATION PROJECTS.

1. To learn to identify 20 fall-blooming wild flowers.
2. To learn to identify 30 common weeds.
3. To learn to recognize 15 fall-blooming garden flowers.
4. To learn to recognize 15 butterflies.

COLLECTION PROJECTS.

1. To collect and mount with labels 20 different kinds of butterflies.
2. To collect, mount and classify 40 different kinds of insects.
3. To collect and mount 20 different kinds of common weeds.

CONSTRUCTION PROJECTS.

1. To make a rabbit hutch that will be fitted for raising rabbits in the back-yard at home.
2. To make a balanced aquarium.
3. To make an insect trap for use in insect collecting.

OBSERVATION PROJECTS.

1. To find out, by observation in the field, how plants are carried from place to place.
2. To find out how many weed seeds may be produced by a single plant.
3. To study and report upon the activities of ants.

B. TOPICAL ORGANIZATION.

Central Topic: Food.

DISSECTION PROJECTS.

1. To determine what food elements are present in milk.
2. To find out what food elements are present in wheat flour.
3. To find out what food elements are present in 10 common foods.

OBSERVATION PROJECTS.

1. To determine by observation the factors influencing the growth of bacteria and molds.
2. To find out what happens during fermentation by watching yeast cultures that are growing.

CONTROL PROJECTS.

1. To find out effective means of checking the growth of common bacteria, yeasts and molds, and to learn to use these means.
2. To make diets for reducing.
3. To make diets for thin boys and girls and keep a record of the gains made by the use of these diets.

Particular attention is called to the fact that internal arrangement of the types just described does not supersede the organization based upon the activities involved. This organization based on activities, although it does not determine just which project should come next, is nevertheless extremely valuable for the teacher as a means of helping to keep in mind possible attainable objectives and as a means of keeping the balance of emphasis upon the student activities through which these objectives are attained. Such an organization is worth keeping for the sake of preserving for the teacher the orientation suggested by the analysis of the teaching process found on page 16 above

The topical organization presents the difficulty of a possible relapse into subject-matter teaching,—the use of the project form for motivating the teaching of pigeonholed subject-matter. At best it seems to be a useful compromise where conditions do not make complete project organization possible. In the

University High School after several trials it was abandoned as not entirely compatible with the spirit of project teaching.

The seasonal arrangement, on the other hand, was found to be quite useful and usable. Indeed, it is almost essential, because many of the projects are dependent upon weather conditions and seasonal changes and must be carried out at certain times of the year or not at all. With this arrangement students are still allowed to select the projects that they are to do. The range of selection is, however, somewhat limited by the type of internal arrangement adopted. The present practice in the University High School is to allow a student who has a definite project to propose to work upon this whether it has any connection with the work of the rest of the class or not, provided his work is approved by the teacher in charge.

The student's selection of projects is controlled in two ways. First, the type of projects suggested by the teacher will influence the selection of the students. If the teacher suggests a particular group of projects many students will work upon the projects suggested. Others who do not work upon those actually presented by the teacher, will be stimulated to propose projects of a similar type. If some students work upon projects of the sort suggested by the teacher, others, through seeing the work done, will ask to carry on similar activities. This sort of contagion spreads every day in a class carrying on project work. Secondly, all projects must be approved by the teacher. If the teacher considers a piece of work of little or no value he can simply refuse to allow the student to carry it out. Such disapproval should usually be accompanied by a statement of the reasons for the lack of approval, but teachers should be firm in refusing to allow students to carry on activities which lead to mere fooling and waste of time.

In carrying out the technique thus far described, several devices were found to be very serviceable. These were the suggestion sheet, the direction sheet, the teacher's follow-up sheet, and the card record file.

The suggestion sheet is simply a suggestive list from which students may choose projects for work. It also serves the purpose of stimulating students to think of other projects. Teachers can readily make up suggestion sheets from the gen-

eral list by selecting from it the sort of projects which they wish for the time being to suggest to students. These projects are presented to the class upon typed or mimeographed sheets. If this is not possible, a blackboard may be used. Students choose projects from this list or make counter proposals.

Following is a sample suggestion sheet:

GENERAL SCIENCE

SUGGESTION SHEET

NAME ....DATE ....

Check (x) in the left hand margin the project, or projects, in this list which you wish to carry on next. If you do not wish to do any of these write out a brief description of the work which you wish to do next on the back of this sheet.

1.	To learn to identify 30 common weeds	10
2.	To learn to identify 20 winter birds	10
3.	To learn to identify 15 shrubs used for ornamental planting	5
4.	To collect and mount with labels 20 different kinds of butterflies	10
5.	To collect, mount, and classify 40 different kinds of insects	15
6.	To collect and label 25 kinds of weed seeds	10
7.	To collect, classify, and label 25 kinds of fruits	5
8.	To collect 10 kinds of water animals for the school aquarium	2
9.	To make a balanced aquarium	2
10.	To make an ant cage, and observe the activities of ants	3

The direction sheets consist of simple and concise directions for getting the students started to work upon their projects. These directions are not detailed laboratory directions. They are merely suggestions to get the students started to work without waste effort. The directions are built up from observation of students' difficulties, from students' plans of work, and from the teachers' experience in solving general science problems. Such direction sheets should be cumulative. Each teacher should build up his own set. If no direction sheets exist, students must make their own. These, in turn, may be used to offer suggestions to other students. It must always be borne in mind that these direction sheets are not to do the work for students. Therefore, students need not follow directions just as they are set down. As soon as such sheets become mere directions to follow, like the recipes in a cook book, they fail to serve their purpose and should be destroyed.

Following are sample direction sheets:

SAMPLE DIRECTION SHEETS

TO FIND OUT HOW A GAS ENGINE WORKS:

1. Read:
   Hodgdon, D. R., *Elementary General Science* pp. 162 ff.
   Smith, W. P. and Jewett, E. G., *Introduction to the Study of Science* pp. 330 ff.
2. Make a list of other books, with page references, which will help you in solving this problem.
3. Go through this material to find worth while facts bearing on your problem.
4. Visit a garage or examine an automobile to watch an engine in operation.
5. Make diagrams to show the operation of all the essential parts.
6. Organize your material for a report of what you have found out to the class.

TO FIND OUT WHAT MAKES THINGS FLOAT:

1. Read:
   Mann, C. R., and Twiss, G. R., *Physics* pp. 87-91.
2. Make a list of other books, with page references, that will help you with your problem.
3. Go through these books and select material that you can use.
4. Select an experiment from one of these books to try out.
5. Make a list of the materials needed for performing this experiment.
6. Write a summary of what you have learned.
7. Prepare a demonstration to show other members of the class why things float.

TO MAKE A MODEL AEROPLANE AND LEARN WHAT KEEPS IT UP:

1. Read:
   Mann, C. R. and Twiss, G. R., *Physics* pp. 312-316.
   Trafton, G. H., *Science of the Home and Community* Ch. 22.
   Smith, W. P. and Jewett, E. G., *Introduction to the Study* of Science pp. 394-401.
2. Make a list of other books, with page references, that will help you in working out this problem.
3. Build and fly a box kite.
4. Try to find out how a box kite is like a biplane.
5. Make a diagram showing the forces acting on your box kite.
6. Compare this diagram with the diagram of the forces acting on an aeroplane in Mann and Twiss, *Physics*.
7. See Goldsmith, M., *Practical Things with Simple Tools* for directions for making a toy aeroplane.
8. Make a model aeroplane and demonstrate to the class how it works.

TO LEARN TO IDENTIFY 30 SPRING BIRDS:

1. Make a list of the birds that can be found in this vicinity in the spring from the list of birds found near St. Louis in the back of Chapman's *Bird Life*.
2. Use this as a check list and check off the name of each bird as you are able to identify it.

3. Make a table showing where to look for each kind of bird. Material for making this table can be found in the bird books in the general science library.
4. Make frequent field trips to places where birds are commonly found. Secure a pair of field glasses from the store-room to help you in seeing colorings and markings.
5. Make notes of your observations. Compare these notes with the pictures and descriptions in the bird books.
6. Make a report to the class on how you learned to know some particularly interesting bird that most members of the class do not know.
7. The following books will help you with this problem:

   Chapman, F. M., *Bird Life*
   Hodge and Dawson, *Civic Biology*
   Reed, C. A., *Bird Guide*
   Trafton, G. H., *Methods of Attracting Birds*
   Apgar, A. C., *Birds of the United States*
   Miller, O. T. *The Children's Book of Birds*
   Weed and Dearborn, *Birds in their Relation to Man*
   Blanchan, N., *Bird Neighbors*
   Hotz, F. L., *Nature Study*
   Pamphlets of the Audubon Society

TO STUDY THE DEVELOPMENT OF FROGS AND TOADS:

1. Secure a net and bucket from the biology storeroom. Visit a near-by pond or creek and secure a handful of frog or toad eggs.
2. Make a battery jar aquarium (See Van Buskirk and Smith, *Science of Everyday Life*), and place the eggs in this.
3. Secure a hand lens from the store-room and examine a few eggs in a watch glass. Make a sketch of an egg.
4. Examine the eggs at frequent intervals and note their development. Make sketches to show this development.
5. Secure zoology texts from the library and find out all that you can about the development of frogs.
6. Read:

   Downing, E. R., *A Source Book of Biological Nature Study*, pp. 43-49.

TO MAKE A BALANCED AQUARIUM:

1. For directions and information on balanced aquaria see:

   Hodge and Dawson, *Civic Biology*
   Van Buskirk and Smith, *Science of Everyday Life*
2. Make a list of the materials needed for your project.
3. Visit the botany pond to secure water plants for the aquarium. Be sure that these are washed clean before they are planted.
4. Secure nets and buckets from the biology store-room and get as many specimens of water animals as possible from the Hinkson.
5. When the aquarium is well established exhibit it to the class and explain to them how the plants and animals live without having the water in the acquarium changed. Explain the carbon cycle by means of a diagram.

TO FIND OUT WHAT FIBERS ARE USED IN 10 SAMPLES OF CLOTH:

1. Read:
   VanBuskirk and Smith, *Science of Everyday Life* Ch. 14 and problems 6, 7, 8.
   Godfrey, *Elements of Chemistry*, Ch. 29.
2. List other books that will help you.
3. See the books in the Home Economics Library.
4. Select experiments that will help in solving this problem.
5. Make a list of materials needed.
6. Furnish as many of these as you can, and secure the rest from the store-room.
7. Write a summary of what you have learned.
8. Prepare a report of your work for the class.

TO LEARN HOW TO REMOVE 10 DIFFERENT KINDS OF STAINS:

1. Read:
   Hodgdon, *Elementary General Science*, p. 271.
   Van Buskirk and Smith, *Science of Everyday Life*, Ch. 14, esp. p. 303.
   Bailey, *Sanitary and Applied Chemistry*, Ch. 8.
   Trafton, *Science of the Home and Community*, p. 116.
   McPherson and Henderson, *First Course in Chemistry*, p. 253.
2. Make a list of the materials needed.
3. Furnish as many of these materials as you can, and secure the rest from the store-room.
4. Write a summary of what you have learned.
5. Be prepared to make a report to the class.

The teacher's follow-up sheet contains the names of all the students in the class, with sufficient space under each name for writing in brief descriptions of current projects. Under the name of each student is written the project upon which he is at present engaged. Notes can be made from time to time concerning the stage of progress of the various students. By a glance at the follow-up sheet the teacher should be able to tell what any student should be doing at any particular time. Such a device also serves as a check to help the teacher keep in mind which students will soon finish projects and which students will need guidance and suggestions in starting new projects. It may act as a warning device, like a bell on a typewriter. The bell on the typewriter indicates that a line is nearly finished. In project teaching the teacher's follow-up sheet will indicate that certain students have nearly finished projects, and that the teacher, therefore, needs to be prepared to help them with new ones. The follow-up sheet, to be of any value, needs to be kept up to date. New ones need to be made frequently. Blank pages containing the names of all

the students in a class can be prepared in multiple with a typewriter and filled in when needed.

Following is a sample of a teacher's follow-up sheet:

GENERAL SCIENCE

TEACHER'S FOLLOW-UP SHEET

Clements, Neal

1. To find out why the wire in an electric grill becomes hot. (Needs to do more reading.)
2. To make an electric motor. (To be begun when No 1 is properly finished. Probably ready Wednesday.)

Curtis, William

1. To find out how the weather bureau predicts the weather. (Make arrangements with Mr. Reeder to allow William to visit the weather bureau Tuesday.)
2. To find out how barometers work. (See if there is a sufficient supply of mercury in the laboratory.)

Phillips, Wendell

1. To make a broomstick Xylophone. (Check over figures to see that lengths figured by Wendell are correct. Should finish this week. Hold conference to agree upon a new project.)

Wallace, Cameron

1. To find out how a siphon works. (Short project. See that no time is wasted in beginning new project.)
2. To find out how pumps work.

Corpus, Lorenzo

1. To find out how the mechanical advantage of simple machines can be determined. (Much difficulty in reading due to difficulties with English. See that he understands what he reads.)

Lansing, Paul

1. To find out how the weather bureau predicts the weather. (To accompany Wm. Curtis Tuesday. Check to see what is learned. Set definite time limit for trip to prevent loitering.)

Fairbairn, Carl

1. To find out how hard water can be softened. (Will need new project soon.)

Lazarte, Aurelio

1. To find out what causes hard water. (Conference with Carl Fairbairn.)
2. To find out how pumps work.

Gilbert, Claude

1. To find out how the mechanical advantage of simple machines can be determined. (Not to work with Corpus. See that independent work is done.)

Boswell, W. R.

1. To make an electro-magnet. (Be sure that W. R. finds out *why* his magnet works.)
2. To find out how an electric motor works.

Holloway, Leslie

1. To find out how simple machines work. (Small group project with Ancel Payne and Dean Vandiver. Ask for group report to class.)

Vandiver, Dean

1. To find out how simple machines work. (See above. See that Dean works upon his own project and does not kill time visiting.)

Payne, Ancel

1. To find out how simple machines work. (See above.)

The card record file is an alphabetical file of students' records of their own projects, made upon 4x6 cards. A description of these records is given in the "Directions for Carrying on General Science Projects," on page 326. Index tabs for the file should bear the names of the students in the class, last name first. These are arranged alphabetically in the file. The record cards of each student are arranged chronologically according to the dates of the beginning of projects in the upper right hand corners of the cards. As soon as a project is finished and approved the teacher should initial the record card and indicate the number of points received by the student in the upper right hand corner above the date.

These records will serve all of the educative functions usually credited to science note books, and at the same time avoid much of the drudgery accompanying the usual note book worry. In order to make the most of this advantage, students should usually be required to confine the report of each project to the front and back of a single card. These cards will furnish the teacher a permanent, concise and convenient record of all the work done by each student in the class. They will furnish one basis for grading students, a fund of material for revision of previous evaluations of projects, and a basis for extension and revision of work for the future. The chief value of this device lies in its helpfulness to the teacher. Its value to the students may possibly be questioned, but its great service to the teacher undoubtedly justifies its use.

(*To be continued*)

Tipless Lamps

By E. B. Fox, The Edison Lamp Works, Harrison, N. J.

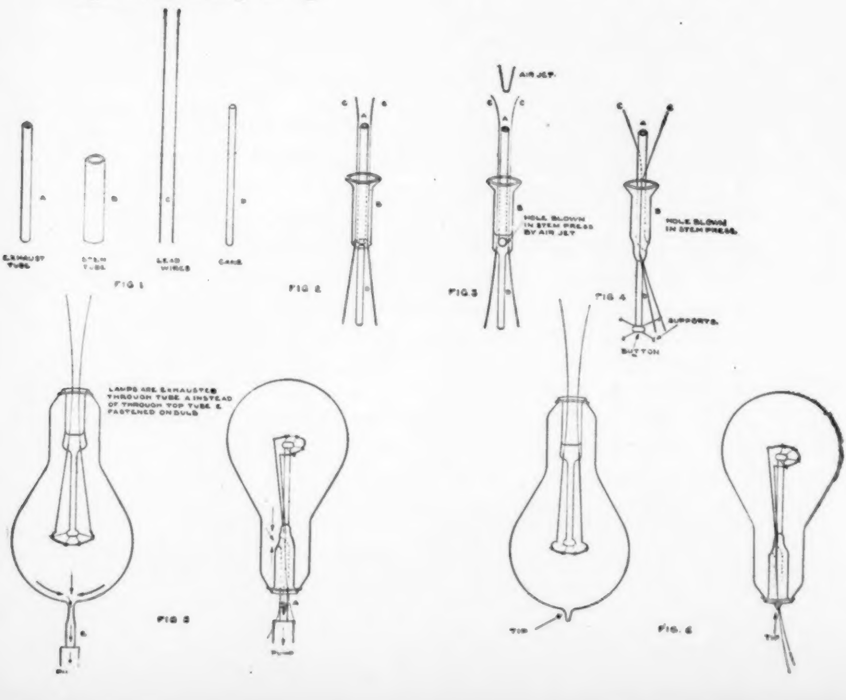
We have often been asked to tell how the White Mazda lamp is made without a visible tip. The general idea is shown in the accompanying figures, leaving out the quite complicated machinery which is required to procure the results.

Fig. 1 shows parts required to make up a stem. The parts assembled are shown in Fig. 2.

Fig. 3 shows this stem nearly complete to form a flat joint between stem tube B and cane D. While the glass is still hot a stream of air is sent through the tube A to blow out a hole in the stem press, so air can later be drawn out through it.

Fig. 4 shows a side view of this stem.

Fig. 5 shows how the air is drawn out of both tipped and tipless lamps by connecting the top tube C or exhaust tube A to the rotary exhaust pumps. After the air has been removed through these tubes they are melted off at points marked tip in Fig. 6. The lamps are now ready for basing, soldering of lead wires to the base, cleaning, labeling, lighting up for inspection, and packing.



Dangers from Carbon Monoxide Poisoning in tne Home

SAMUEL S. WYER, Consulting Engineer, Columbus, Ohio.

LIFE HAZARD. During the first ten weeks of the winter of 1922 and 1923 there were 81 carbon monoxide asphyxiation cases in Ohio, of which 34 were fatal. All of these were preventible and could easily have been avoided by the application of the principles stated herein. This high death rate was not peculiar to Ohio, but has been general, and as the London *Lancet* has aptly stated, "Carbon monoxide is rapidly becoming a modern terror, for undoubtedly the number of victims is decidedly on the increase."

The flueless gas-heating device is the most serious menace in the home. As there are over 2,000 natural gas using towns and over 4,600 manufactured gas using towns in the United States, and either natural or manufactured gas is used by over one-half of our population, the wide interest is obvious.

DEFINITION OF CARBON MONOXIDE. Carbon monoxide is the product of incomplete combustion; that is, burning without sufficient air to secure complete burning to carbon dioxide.

PROPERTIES. Carbon monoxide is an odorless, colorless and tasteless gas that cannot be detected by any of the senses. It is such a deadly poison that one-tenth (0.1) of one per cent is enough to in time produce fatal results. Six hundredths (.06) of one per cent will produce perceptible effects on the human system.

ODORS GOING WITH CARBON MONOXIDE FORMATION. Although carbon monoxide itself is odorless, when it is formed vapors having an offensive acetylene-like smell are produced and these offensive vapors have a marked irritating effect upon the eyes, causing watering and soreness, and also injure the throat and nasal passages. It is almost universal that when these offensive odors are perceptible that carbon monoxide is being formed.

ACTION OF CARBON MONOXIDE. Carbon monoxide combines with the hemoglobin of the blood and temporarily destroys its function as an oxygen carrier. After continued exposure a large part of the hemoglobin becomes inactive, depending on the concentration of carbon monoxide present in the atmosphere. The affinity of carbon monoxide for hemoglobin is 250 to 300 times as great as oxygen, and it is easily seen why a small percentage of carbon monoxide soon becomes very dangerous to health when inhaled for some time. That is, the human system is the best known absorber of carbon monoxide.

SYMPTOMS. "Carbon monoxide produces a tired feeling, headache, nausea, palpitation of the heart, sleeplessness, and sometimes mental dullness. The victim of acute carbon monoxide poisoning usually experiences the following symptoms: Yawning, sleepiness, tiredness, a feeling that the skin is tightly stretched across the forehead, and a frontal headache, at first dull and intermittent, and later more severe and continuous. Later, this headache is replaced or masked by a typical one at the base and back of the skull, which causes the sufferer to hold his head back as far as possible, in an effort to obtain relief. Dizziness, nausea (feeling of sickness), and lassitude also occur. The pulse is at first normal, but later becomes full and rapid; the skin is flushed; the respiration become more rapid with exposure to the gas, and later irregular. If the exposure is sufficiently long, or the concentration sufficiently great, confusion and unconsciousness develops. The nausea may be sufficient to produce vomiting. All the symptoms are accentuated by exercise, eating, and stimulants. When a man is overcome by large concentrations of the gas, the symptoms follow each other rapidly, and he may quickly fall unconscious."[1]

In some cases, when the percentage of carbon monoxide is small, the action is so insidious that the patient simply goes to sleep without experiencing any of the above symptoms. In other cases, where the percentage of carbon monoxide is large, the stupifying action will be so rapid that the patient in becoming unconscious does not experience any of these symptoms.

1 Dr. R. R. Sayers, Chief Surgeon, U. S. Bureau of Mines, Washington, D. C.

AFTER EFFECTS. The reports of many post mortem examinations show conclusively that carbon monoxide poisoning is predisposing to the development of pneumonia and many other serious diseases.[2]

FIRST AID TO VICTIM. Remove the victim from the contaminated atmosphere and send for a physician. The proper administration of pure oxygen will usually give immediate relief. If the victim is unconscious, use artificial respiration.

HOME SOURCES OF CARBON MONOXIDE. The charcoal braziers so extensively used in Franklin's day for room heating, so vitiated the air that he was prompted to invent, in 1742, what has since been known as the Franklin stove, or "Pennsylvania fireplace." This was primarily the application of proper flue connections and air ventilation to a heating device. Due to the large use of flueless gas-heating stoves at the present time, we have practically reverted to the hazardous conditions that prevailed in Franklin's day.

Coal stoves or furnaces will, at times, produce carbon monoxide, and if they are not tight the gas may leak into the room. There are several known asphyxiations from this source.

Practically all manufactured gas contains carbon monoxide, and this is the poisonous agent that produces death when raw manufactured gas is inhaled.

The exhaust gases from automobiles always contain carbon monoxide, and when the engine is first started the percentage is unusually high. Automobile exhaust gases are, therefore, extremely dangerous, especially in connection with small garages around the home. There are a large number of fatal asphyxiations from this source each year. The floor heaters utilizing exhaust gases in many closed cars, due to defective construction, may permit the exhaust gases to get into the car and produce dangerous conditions.

The greatest sources of danger in the home are flueless gas hot-water heaters and flueless gas heating stoves.

WHAT MUST HAPPEN WHEN GAS IS BURNED[3]. The combustion—that is, the burning of gas—can take place only by

2 For extended discussion, see "Gas Poisoning," by Dr. Glaister.

3 From here on the discussion follows Smithsonian Institution Bulletin 102, Part 8, "Manufactured Gas in the Home."

first mixing the gas with the proper proportion of atmospheric air. With natural gas, from 9 to 11 cubic feet, and with manufactured gas from 4½ to 5½ cubic feet of air must be mixed by the gas consumer at his burning appliance with each cubic foot of gas in order to insure perfect combustion. If not enough air is mixed with the gas, the combustion will be imperfect and will form carbon monoxide.

When natural gas is burned by complete combustion, each cubic foot of gas will form about one cubic foot of carbon dioxide and two cubic feet of steam. When manufactured gas is burned by complete combustion, each cubic foot of gas will form one-half cubic foot of carbon dioxide and one cubic foot of steam. This carbon dioxide is the same substance that is exhaled from the lungs.

The combustion of 1,000 cubic feet of natural gas will form water vapor or steam, which, when condensed, will make approximately 10½ gallons of water. The combustion of 1,000 cubic feet of manufactured gas will form water vapor or steam, which, when condensed, will make approximately 4½ gallons of water. It is this water vapor that causes the bakers and broilers of stoves and flue connections to rust. When gas is used in open fires without flues, it may make the walls and windows "sweat."

TWO KINDS OF GAS FLAMES. (a) Bunsen or blue flame. In this, part of the air must be mixed with the gas before reaching the flame. There will always be an inner cone--of different shade—as shown in Figure 1. Improper adjustment may make a yellow flame and carbon monoxide. This kind of flame is used on all mantle lamps, cook stoves, water heaters, and most room heaters, including the radiant type shown in Figure 3.

(b) Luminous flame. If only a small quantity of gas is forced out through a hole about the diameter of a pin, as shown in Figure 2, enough air from surrounding atmosphere can be mixed with the gas to insure perfect combustion. The flame must not come in contact with any solid body or carbon monoxide will be formed. This flame can be used for room heaters only.

WHAT MAY HAPPEN WHEN GAS IS BURNED. If the com-

bustion of gas is not complete, carbon monoxide is formed instead of carbon dioxide. This poisonous gas is especially likely to be formed:

a. During first few minutes' operation of any automatic water heater.
b. When the inner cone of any blue flame—see Figure 1—impinges on a cool surface.
c. When a luminous flame—see Figure 2—is deflected and impinges on a cool surface.
d. When any flame is not supplied with sufficient air.
e. When a radiant-fire heater is operated so that the radiants glow more than ¾ of the distance from the bottom to the top, as shown in Figure 3.

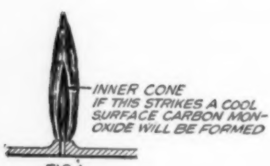


FIG. 1.
BLUE FLAME
BUNSEN BURNER

FIG. 2.
LUMINOUS FLAME
BURNER

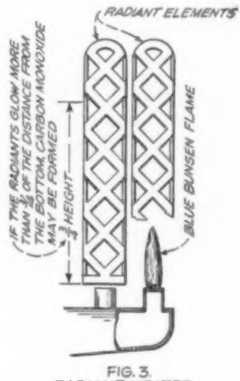


FIG. 3.
RADIANT HEATER

COMBUSTION PRODUCTS OF GAS CANNOT BE ABSORBED OR DESTROYED. The inevitable products, carbon dioxide and water vapor, cannot be destroyed, although the water vapor when it is cooled will condense to a liquid. There have been many claims made by manufacturers of heating devices that their devices absorb the combustion products, but all such claims are untruthful.

FLUELESS HEATING STOVES ALWAYS DANGEROUS. There are many so-called "odorless," "smoke consuming," and "chimneyless" gas-heating appliances in use. These are always dangerous and a positive menace to health and never

ought to be used. Much depression and lassitude of spirit, lower vitality and hence less resisting power to the ever present disease germ may be traced to gas fumes from flueless gas heating stoves.

WHY FLUELESS HEATING STOVES ARE MUCH MORE DANGEROUS THAN FLUELESS COOK STOVES. In the kitchen the cook stove is seldom used for more than one hour at a time. The volume of steam from the cooking food will be much greater than the volume from the combustion products from the gas, and the steam alone will make ventilation necessary.

The person in the room will be constantly moving about, with head four to five feet above the floor level, and in all probability the kitchen door will be opened several times during the cooking, thus increasing the ventilation.

In contrast with this condition, when a heating stove is used in a bedroom or bathroom, the period of use is much longer, the ventilation is less, the person in the room will be quiet, with head closer to the floor, and the doors will probably, at least in the bedroom, not be opened or closed. Furthermore, a flueless stove properly adjusted at 9 o'clock in the evening, when the person goes to bed, may become a carbon monoxide generator several hours later, due to deflection of the flame or small change of pressure, when the person is asleep.

Enrollment in Science in Large High Schools

Statistics received by the Bureau of Education for 1921-1922 from public high schools in cities of 100,000 or more, show the following enrollment in the various sciences:

Sciences	Per cent of High School Pupils Enrolled	Sciences	Per cent of High School Pupils Enrolled
Astronomy	.10	Zoology	1.23
Physics	8.59	Biology	8.96
Chemistry	8.88	Geology	.17
General science	14.84	Physiology	4.61
Physical geography	2.68	Hygiene and sanitation	11.71
Botany	2.89	Agriculture	.27
		Home economics	12.47
		Electricity	.23

Physics A Hundred Years Ago

A. S. Eve, McGill University, Montreal, Canada.

A century ago science had recently lost three eminent men who had notably advanced our knowledge of electricity, dynamics and heat: Cavendish (1731-1815), Rumford (1753-1814), Watt (1736-1819).

The steam engine had appeared and was used for pumping mines, for locomotives, and for the propulsion of ships; the notable discovery had been made, to quote the contemporary words of John Herschel, that "A man's daily labor is about four pounds of coal." "Two pounds of coal would raise a strong man from the Valley of Chamounix to the top of Mt. Blanc." "You can raise seventy million pounds weight a foot high by a bushel of coals."[2]

There had just begun that industrial revolution due to the use of coal and iron, which, for better or worse, has in a century transformed the world.

Every age regards its progress with a wholesome and justifiable pride. The achievements of preceding generations are dimmed in lustre by familiarity. The imagination is too feeble to form an adequate conception of the marvels awaiting discovery, ready to fall like ripe plums into the laps of successors. On the other hand, recent discovery always stands out with a delightful and refreshing vividness.

Now a hundred years ago people were thoroughly pleased with their discoveries, no less than we are today. It is sufficient to mention such successive discoveries as the spinning jenny (1768), spinning frame (1769), cotton gin (1792); the discovery of the planet Uranus (1780), the first air balloon (1783), and vaccination (1796).

Thanks to Newton and others, it was a just claim, in 1821, that more scientific progress had been made in the preceding two hundred years than in the whole previous history of mankind.

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1 Address at the Centenary Reunion of McGill University, printed in "Journal Franklin Institute," December, 1921.

2 The actual work done by a bushel of coals used in a steam-engine was called its "duty," a useful term.

It is curious to read moreover the lamentations by Thomas Young on the enormous amount of scientific literature and the great variety of publications, which rendered it difficult or impossible to keep abreast with scientific discovery. How seriously has this evil increased during the past hundred years, until we seem doomed to be buried under our own records! And this trouble must continually increase with time.

Mr. James McGill was an enlightened citizen of Montreal with an interest in literary and scientific progress. It requires but a small stretch of the imagination to conceive of our founder sitting under an elm tree on Burnside Farm by the side of that little brook, with its rustic bridge and lovers' walk, which flowed past the spot where the Macdonald Physics Building now stands. The valley of that brook is still visible in the back lane and tennis court. And indeed in spring time, the brook itself revives and floods our basement.

Imagine him seated there and reading the following fictitious letter, supposed to have been written about a century ago by a friend of James McGill, an imaginary professor of natural philosophy at the famous University of Glasgow, giving an account of a visit to London and Paris, and describing to our founder what he saw which was new and interesting in the scientific field. It is a matter of regret to me that I cannot read this letter to you in the good Scots tongue.

From Professor Robin Angus,
The University of Glasgow.
(Undated)

To Mr. James McGill,
of Montreal.

Dear Mr. McGill,

I am now fortunate in writing to you to give my promised account of a long projected visit to London and to Paris, and my description of the progress of recent discovery in natural philosophy.

I left Glasgow on the first of June and the roads were in good condition, so that we made a swift and agreeable journey. One day indeed we traveled 59 miles in 11¾ hours, including time for baits!

On my arrival at London I quickly went to the Royal Insti-

tution and called on Dr. Thomas Young. I was fortunate enough to hear one of the 93 lectures which he is giving on natural philosophy. These lectures are shortly to be published as a book, a copy of which I will send you. His lectures were well illustrated by skillful experiments.

You are aware that Sir Isaac Newton suggested that light consisted of little bodies or corpuscles shot from the source of light, traveling "with an eel-like motion" along straight lines. Now Dr. T. Young will have none of this theory, but he agrees with Huyghens that light travels with wave motion in some subtle and all-pervading medium which is called æther. Huyghens thought that light consisted of waves with a motion of the æther to and fro in the direction in which light traveled, but Doctor Young points out, as did Newton, that light may be "one-sided" or polarized, so that it is essential to believe that the vibrations are transverse or perpendicular to that direction in which light moves. As indeed the French philosophers have very clearly proved.

Doctor Young has a large trough with a glass base, filled with water, illuminated beneath; and with a large mirror he projects upon a white screen the waves which are made upon the water by one or more pointers fastened to vibrating rods. In this manner he illustrates very clearly what is called the interference of light, well enough known to Newton, but a stumbling-block to his corpuscular theory.

At the Royal Institution I met also with Sir Humphrey Davy, who has saved countless lives of miners by his safety-lamp, where the flame is surrounded by fine wire-screen, preventing premature explosion.

The great Corsican ogre, Napoleon, scourge of the world, is newly dead. Yet, in fairness it must be stated that he proved a good friend to science. In the midst of the war between England and France he gave, in spite of strong opposition, a great scientific prize to an Englishman, Davy, for his discovery of potassium and of sodium by electric separation. He caused a galaxy of scientific men to gather at Paris, and encouraged them in their work by every means at his disposal. Napoleon was a man who certainly knew that in science, too, "As a man sows, so shall he reap."

I met at the Royal Institution a young assistant of Davy's named Faraday, who was full of insight and enthusiasm, so that he promises to go far. He was greatly interested in electrical experiments.

You are familiar with electrical machines and Leyden jars, lightning rods and Franklin's experiment with the kite, and how he obtained electricity from the clouds. All these are well described in a little book by Doctor Priestley which I sent you last year. But, as the Hon. Mr. Cavendish wrote, "It must be confessed that the whole science of electricity is yet in a very imperfect state"; or to quote my friend Doctor Young, "The phenomena of electricity are as amusing and popular in their external form as they are intricate and abstruse in their intimate nature."

Suddenly there has come from Denmark a great burst of light, which we owe to Hans Christian Oersted. This illustrious man was born in 1777, and after passing with honours at school, he received *free* residence and a small scholarship awarded to needy students. After a distinguished career at Elers College, he received a Cappel Traveling Fellowship, which enabled him to visit the leading scientific men in Germany and France, to his great benefit as it now proves to ours.

This plan of helping able students to secure a good university education and to visit other countries in order to appreciate scientific progress, has much to commend it to other countries and to all universities.

Many philosophers have endeavored to deflect a magnet with electricity, using an electrical machine with open circuit. Now Oersted was lecturing to his advanced students and he discovered, his class being there and then assembled, that with an electric battery and a closed circuit he could cause a current of electricity to deflect a magnet. Not when the wire is perpendicular to the needle, but when parallel. This influence will pass through wood and water and mercury and metal plates, excepting iron, so that the influence of the electric current on a magnetic pole is, as it were, in circles around the wire. Already Schweigger, at Halle, has invented a measurer of electric current called the Astatic galvanometer, where two equal magnetic needles pointing opposite ways have been deflected by

a current passing in a coil of wire round one needle, a most sensitive arrangement.

Davy, using the great battery of 2,000 cells of zinc and copper at the Royal Institution, has passed an arc between two carbons giving a most brilliant light. Now this arc he has deflected with a magnet, showing that as a current in a circuit will deflect a magnet, so will the magnet deflect the circuit if and when a current passes in it. Here then we have another example of the third law of Newton, that "action and reaction are equal and contrary." Nay! Oersted himself hung up by a fine wire a small battery and coil and deflected it with a magnet. Hence we now have a new branch of science, my dear Mr. McGill, which we may call electrodynamics or electromagnetics. The great M. Ampère at Paris has made vast strides in this new subject.

And indeed I must pass over much that I would wish to tell you that I saw and heard in London, and proceed with my visit to Paris, which I reached safely after a troubled crossing over the Channel.

In spite of the recent wars, most cordial relations have speedily returned between scientific men of all countries.

I have met M. Ampère, who, stimulated by Oersted's discovery, has extended it and proved that "two parallel and like-directed currents attract each other, while two parallel currents of opposite directions repel each other."

It may be truly said that "the theory and experiment (of electric currents) seem as if they had leaped full-grown and full-armed from the brain of the 'Newton of Electricity.' The theory is perfect in form and unassailable in accuracy, and it is summed up in a formula from which all the phenomena may be deduced and which must always remain the fundamental formula of electrodynamics."

But I must pass on, my dear Mr. McGill, to other branches of natural philosophy. I must name the illustrious M. Chladni, whom they call "the Father of Acoustics." Him Napoleon summoned to show his experiments on sound, and gave a grant of money towards the publication of his book. Galilei first experimented with dust on vibrating metal plates struck by a chisel, but Chladni made great improvements by using lyco-

podium dust with sand. He separated thus the quiescent from the turbulent regions; for, as Faraday has explained, the light lycopodium dust is caught in the whirlwinds of air and finally comes to rest below them, while the heavier sand is driven to the nodes. I have been informed that in recent wars sand has been placed on a drum and the direction of underground mining has been found by the displacement of the sand on the top of the drum set vibrating by the distant blows on the ground of the picks of the enemy. An ingenious application of Chladni's figures!

Most interesting of all are the speculations about light, founded on the most ingenious experiments carried out by Fresnel and Arago. They experiment with "one-sided" or polarized light and secure interference between two rays from the same source, polarized in the same plane, which cannot be done when the rays are polarized at right angles. This is strong evidence for the wave theory, but a challenge was given that a small round body like a coin should have a bright spot in the center of its shadow from a small bright source of light. In truth, and it should! And the difficult experiment was triumphantly carried out by M. Fresnel!

Beautiful and interesting experiments have also been carried out by M. Malus on the polarization of light, and splendid color effects have been achieved with the interference of polarized light passing through crystals of mica, gypsum, or quartz.

The simplest interference experiment is to pass light through a slit and hence through two slits close together. On a screen behind you can perceive bright and dark bands alternating, which prove that two lights can make darkness, which seems impossible with material things, but is readily explained with waves, for we have all seen, on a lake or pond, crests or troughs of waves cancel one another.

There is great encouragement given to science in these days. Thus the famous Euler received a grant of £20,000 in the last century, and the British Government offered a prize of £20,000 for finding the longitude at sea within thirty miles.

Space has not permitted me to write of Fourier, a great mathematician who has established most fundamental prin-

ciples of the flow of heat. His work, "Théorie de la Chaleur," has in his own lifetime passed into a classic.

But what shall I say of Laplace, author of "Mécanique Céleste," now seventy years old, comparable only with Newton, who has been honored by all political parties in the turbulent periods passed by France in his long life. A man more admired than loved, perchance! Laplace has advanced the theory of tides, explained the origin of the sun and planets from a nebula to its present state, and proved that all bodies of the solar system are stable, and may have been so for periods of vast antiquity.

In the spectrum of the sun, Wollaston (1802) and Fraunhofer (1815) have found a very great number of dark lines, which await explanation from succeeding generations. Here indeed we have a great mystery!

But I fear, dear sir, that my letter has far outstripped your patience. Your friends in Glasgow and in Scotland learn with pleasure and interest your scheme for founding a College for the Advancement of Learning in Montreal. Judging from what I have seen in Scotland, in England and in France, such an institution may bring lasting lustre to your name and yield priceless fruit throughout succeeding ages.

Believe me, honored sir,

Your most respectful servant,

Rob. Angus.

* * * * *

As for the information conveyed in the fictitious letter, it is gathered mainly from contemporary sources, and the lectures by Dr. Thomas Young, afterward published as a Treatise on Natural Philosophy, are a great mine of information. But a more valuable source is Mrs. Kirstine Meyer's recent essay[3] on the Life of Oersted. For in 1801 Oersted went to Weimar, Berlin, Gottingen and Paris; he saw Ritter's electrical experiments and the very first storage battery,—copper plates with damp cardboard between, which retained a charge for some time after it was connected to a battery, capable also of generating a current after being charged. In 1812 and '13 Oersted again visited Berlin and Paris, and from autumn, 1822, to the summer of

3 See "Nature," 16, June, 1921.

1823 he visited Germany, France and England, although he was full professor of natural philosophy at Copenhagen at the time. . . . As a result Oersted founded electrodynamics, for he proved that a coil of wire with a current round it was the equivalent of a magnet.

This fundamental result, developed by Ampère, Faraday, Maxwell, and many other co-workers, is the seed of the fruitful results or harvest which you see around you today. I refer to electric motors, lamps, dynamos, generators, electric irons, cookers, bells, toasters, cleaners, and no less to telephones and telegraphs.

We can rest assured that if you give due encouragement and assistance to your quite ablest boys at schools, and to students and professors at universities, there are other and greater conquests of science, of which we have little or no conception today, awaiting discovery and development, and that you must not hesitate to encourage pure research, at unpromising subjects even, rather than endeavor too much to secure industrial research on a commercial basis. The pioneer work is truly of the greater importance, though less likely to secure the appreciation of manufacturers, of politicians, of practical men, and of the public at large.

Here I must interpose a story. About fifteen years ago, one of my predecessors, Professor John Cox, gave a lecture in this theatre on the passage of electricity through rarefied gases, combined with some wonderful experiments, all with the skill and eloquence of which he was and is still a master. Now Sir William Macdonald was present, and he remarked afterward, "How beautiful and how useless!" Yet it is the study of those very phenomena which has led to most notable recent developments in radiology, for example the Coolidge tube, in long-distance and guided telephone, in wireless telephony and telegraphy, particularly by the use of the electronic valves.

But Sir William appears to have been himself a convert before his death. As donor to McGill of this Macdonald Physics Building, as founder of the two Macdonald chairs of physics, he was present at a lecture given by Sir Ernest Rutherford on some of his recent work on radioactivity, and after the lecture Sir William stated that "if all the money spent on the

endowment of physics at McGill had produced no other result but Rutherford's work on radioactivity alone—the money would have been well spent!" . . .

Oersted in 1822 and '23 was not very enthusiastic about German science. "Schweigger, at Halle, has brains, but is a reed shaken with the wind. His experiments are not of much importance. Kastner, at Erlangen, writes thick volumes compiled with much toil but without all judgment. Yelin, at Munich, makes indifferent experiments and lies much." (Really, really, Yelin, this is too bad!) "But I have found much that was instructive with Fraunhofer, at Munich, so that I have been able to occupy myself with benefit there for about a fortnight." But he writes to his wife from Paris, in February, 1823: "My stay here grows more and more interesting to me every day. The acquaintances I have made grow every day more cordial and intimate." He saw Biot, Fresnel, Poillet, Ampère, Arago, Fourier, Dulong, and many others; such was the brilliant list of physicists there at work at Paris. He had long discussions with Ampère on his famous theory, still accepted, that magnetism consists of electric currents in the molecules—electron currents or oscillations as we should perhaps say today. Oersted adds: "On the 10th I was at Ampère's by appointment, to see his experiments. He had invited not a few—he had three considerable galvanic apparatus ready; his instruments for showing his experiments are very complex; but what happened? Hardly any of his experiments succeeded. He is dreadfully confused, and is equally unskillful as an experimenter and as a debater." This report is in strange contrast with the written records of Ampère, which Maxwell has described as the work of the "Newton of Electricity," "perfect in form and unassailable in accuracy." Perhaps Ampère had had the best of an argument!

What then has been added in the last hundred years? Well, the answer to that question will depend on whether you are a so-called practical man or a theorist, whether you are most interested in the applications and practical achievements of physics or in the great principles and theories which underlie the theory and from which the practical applications necessarily arise.

The last hundred years have speeded up all human activities. It now takes days for matter to cross the Atlantic instead of weeks, as then; while messages are flashed across almost instantaneously. A hundred miles a day by coach or on horseback was a strenuous journey; a thousand miles a day by rail is to-day not formidable.

It has been argued with much force by R. A. Freeman in his "Social Decay and Regeneration," that mankind has suffered to a terrible extent by the great access of power which science has suddenly placed in its hands, and it may well be doubted if society is yet fitted to receive fresh gifts of energy from the hands of science. Moral development and social organization has lagged behind scientific progress. Human nature is stable and ill fitted to adapt itself to changes of the magnitude and variety of the last three generations. The resultant instability of modern conditions has shown itself to the greatest extent where the attempted assimilation has been most rapid and ill digested. Petrograd stands out as a prominent and inconceivable wreck, through the mirage of a prostrate Russia.

When we turn our attention to the intellectual achievement of physics, we see a far more attractive picture. The last hundred years have seen the almost complete development of the science of electricity. The great principle of the conservation of energy, established by the insight of Joule, Kelvin, Helmholtz and others, stands, together with the Second Law of Thermodynamics, as the main prop of all physical conceptions. The isolation of the electron, the discovery of its properties, experiments with alpha and röntgen rays and immense developments in modern spectroscopy, are illuminating a vivid conception of the structure of the atom. The present century is responsible for the new branch of physics, and in this very place Rutherford delved deep and built high in radioactivity, and we are all gathered together at a "veritable shrine," already venerated as such. We are passing to a new outlook where energy becomes dominant, so that not only does matter appear to be energy, but space, linked with time from which it is inseparable, is regarded as a continuum of energy mainly.

Most important of all is our revision of fundamental conceptions on a more comprehensive scale, in accord with the general

scheme of the universe of which we are denizens, embraced in the fascinating and far-reaching Principle of Relativity.

Those only who have specialized in modern physics are familiar with the strange elusive problems embraced in the Quantum Theories of Energy.

An atomistic theory of matter is easy to conceive. A corpuscle of electricity, now called an electron, with well-marked properties, electric and magnetic, is not too obscure. But bundles of energy, or quanta, of magnitudes varying with and proportional to the frequency of the propulsive electromagnetic vibrations, present formidable obstacles to the human intelligence, and yet some such entities pervade modern research and are today most fruitful of actual philosophical progress.

I wonder what my successor, lecturing here one hundred years hence, will be saying about relativity and about quanta!

Making Steam Electrically[1]

By R. W. CHADBOURN.

THE electrical generation of steam! Sounds like putting the cart before the horse, perhaps? Practically unknown before the war, still unfamiliar to most of us, perhaps hardly heard of by some of us, the electric boiler has so far won its way into the favor of engineers that it is estimated by a prominent French authority that today there are in use or under construction in the entire world several hundred electric boilers, capable of transforming an aggregate of half a million horsepower of electrical energy into the mechanical energy of steam. That is, if all these units were concentrated in a single area, it would require two generating stations of the capacity of L Street running right up to the limit to supply all of them at full load.

The pioneer work of putting the electric boiler on a commercial basis appears to have been done by the Italian engineer, Revel, who, in 1902 and the years that followed, designed several installations. One of these, dating from 1907, util-

1 "Edison Life," Boston, Aug. 1923.

ized units of 800 H.P. each, and operated directly on 6,000 volts.

Since the war, the development of the electric boiler has been rapid, particularly in the mountainous sections of Europe, where coal has been very expensive and hydo-electric energy cheap. In very recent years, its use has spread to this continent, notably Canada, where units as large as 25,000 KW.—equal to the capacity of three of our largest Edison substations—have been in successful operation.

Recently the Standardizing and Testing Department had occasion to assist Mr. N. J. Neall, consulting electrical engineer of Boston, in an investigation and tests on a large unit in northern Maine, and it was thought that a description and a brief discussion of some of the elements involved in this ingenious, but little known, application of electric energy, might be of interest.

Perhaps the first thought that suggests itself is: Where would an electric boiler be used? In the industrial establishments around Boston, for instance? Or for our steam house-heating systems?

No; under the conditions met with in many of our large power centers, i. e., electric power produced from coal or oil fuel and sold at a relatively high kilowatt-hour rate, as in Boston, for instance, electric steam generation cannot compete with steam produced directly from fuel. The electric boiler has a rather special field of application. With few exceptions, it is used where the cost of energy is slight.

For instance, hydro-electric plants commonly have a certain amount of what may be called "surplus power," that is, the difference between the power available and the normal load at any instant. In the off-peak periods, such as nights, holidays and Sundays, and in times of high water, this may be considerable. Electric boilers can profitably use this surplus power at practically no additional expense to the power company, and so obtain large amounts of energy at a very favorable rate. One criticism of this sale of off-peak power is that it tends to promote the illusion among consumers that hydro-electric power costs nearly nothing.

Again, electric boilers are largely used by plants which

generate their own power hydro-electrically, in which case the cost per kilowatt hour does not enter into the problem. One conspicuous application of the boiler is in the large paper mill of northern New England and Canada, which uses large amounts of steam for its pulp digesters and the drying rolls of the paper machine, and either generates its own hydro-electric power or obtains it at a very favorable rate from the local electric company.

Electric boilers may sometimes be profitably used for the maintenance of pressure in central stations during the hours when coal boilers are shut down. A further aplication is in the heating of trains drawn by electric locomotives. There are numerous other special cases where small units may profitably be employed for general heating purposes. An example of this is a small unit used to heat a hydro-electric power house within fifty miles of Boston.

The electric steam generator is, *per se,* like the electric transformer, a highly efficient unit. All the electric energy is converted into heat, the loss consisting of the small amount that may radiate through the heat-insulated shall or be withdrawn in the process of "bleeding" the boiler, i. e., discharging a certain amount of water to carry away the accumulated impurities. 1 KW.H. = 3,412 B. T. U. Assuming steam at 150 lbs. per sq. in. absolute, raised from a feed-water temperature of 150° F. the total heat required per lb. = 1,075 B. T. U. 1 KW.H. will, therefore, produce 3,412 ÷ 1,075 = 3.17 lbs. of steam. Assuming 98% efficiency, this becomes 3.10 lbs.

The relation between KW. and boiler H.P. may be found as follows: 1 boiler H.P. = 33,479 B.T.U. per hour. 1 KW. = 3,412 B.T.U., or, at 98% efficiency, 3,342 B.T.U. per hour. Hence, 10 KW. give almost exactly 1 boiler H.P.

Electric boilers are of two general types: (a) induction boilers, which utilize the eddy current and hysteresis losses in a mass of iron for heating the water, and (b) resistance boilers, in which heat is produced by the passage of current through suitable resistance.

Induction boilers are not common, are usually more expensive to construct, and have the serious disadvantage of low power factor,—from 0.5 to 0.7 lag. Resistance boilers operate

at practically unity power factor. This class may be subdivided into: (a) boilers which use metallic resistors, and (b) boilers which make use of the resistance of the water itself.

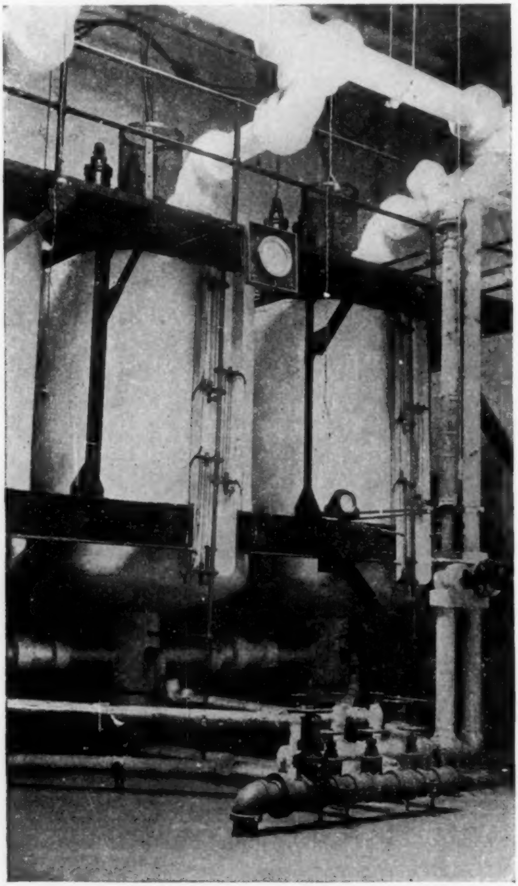

Fig. 1. Two Tanks of 3-Phase 17,000 KW. 11,000-Volt Electric Boiler.

The first class usually employs high resistance alloys not easily oxidizable, such as nickel-chrome, which are sometimes protected from the water and sometimes not. Control is ob-

tained by varying the number of units in parallel. Units of this type cannot be used on voltages much over 500, so their capacity is quite limited. Other disadvantages are the complicated methods of control and the possibility of injury to the heating elements in the event of low water.

For high voltages and large powers, the type using the water as the resisting material is in general use. This type of boiler cannot be used on direct current because of electrolytic action, and the resultant generation of highly deleterious gases, such as oxygen and hydrogen. Three-phase A.C. is commonly employed. For moderate capacities at moderate voltage, up to say 2,200 volts, a single tank is used, three electrodes, each properly insulated from the tank, being introduced at one end. Each electrode is connected to a phase of the supply circuit, the tank serving as a grounded Y-point.

For larger powers at higher voltages, separate tanks, one to a phase, are commonly used, the various tanks being tied together electrically and forming a grounded Y-point. This circuit scheme may be subject to the flow of third harmonics where the generating end is grounded, or to excessive surging of the boiler load where the generating end is ungrounded and intermittent grounding occurs.

The accompanying photograph shows the exterior construction of a 16,000 KW. unit, designed to operate at 11,000 volts. This is rather higher voltage than is commonly employed, most of the present installations not exceeding 6,600 volts.

The resistance of the water path, and hence the load on the boiler, may be and are commonly varied by changing the electrode immersion. This is achieved by actual raising or lowering of the electrodes or by changing the water level. The latter is the usual control, the adjustment being made by manipulation of the feed-water valves by the boiler operator. It is evident that the resistivity of the water is an all-important factor in this type of boiler; in fact, it is necessary to design a given boiler to fit the water which is to be used in it.

When a boiler is generating steam, concentration of the water in the boiler takes place, since the solids are largely behind when the water is evaporated. This results in a continual decrease in the resistance of the water, which calls for a con-

tinually decreasing immersion to maintain constant load. In practice it has been found that an advanced stage of concentration results in certain electrical and chemical difficulties. This excessive concentration is prevented by "bleeding" the boiler, i. e., withdrawing part of the water in the bottom, either occasionally or continually.

Fig. 2 shows a cross-section of a tank of a typical 3-phase unit. The live electrode enters the boiler at the top, through an insulating bushing, the whole being readily removed for

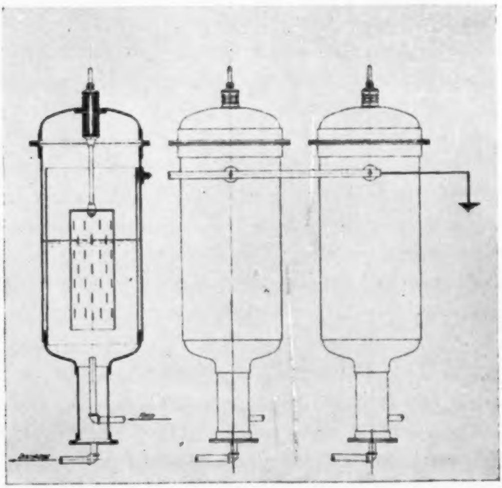

Fig. 2. Sketch showing Mechanical Details of typical 3-Phase Electric Electric Boiler.

inspection or replacement. The electrode in this case consisted of a piece of large iron pipe. Other forms, such as a number of rods, have been successfully used. Bleeding is accomplished through a pipe at the extreme bottom, and feed water is introduced just above the bottom. Each tank has its own feed and bleed valves, all so located as to be easily manipulated by a single operator.

The electric boiler has numerous advantages over its cousin, the coal-fired unit:

(1) Cleanliness. The boiler gives no smoke or soot. The metal surfaces do not scale so readily as in a coal-fired boiler, because of their lower temperature.

(2) Ease of starting up and shutting down. The boiler can be started very quickly by regulating the feed-water valves and closing the line switch. Steam will begin to generate in a very short time. Shutting down is equally simple.

(3) Low cost of installation. The electric unit and auxiliary apparatus is extremely simple, hence cost of installation is low. Electrical equipment includes switchboard with ammeters, watt-hour-meter and relays, and oil circuit breaker, and disconnecting switches.

(4) Small space requirements. A 25,000 KW. electric boiler giving 2,500 boiler H.P., requires, including the necessary electrical equipment, approximately 1,200 square feet of floor space. The corresponding capacity in coal-fired units would require perhaps 6,000 square feet, exclusive of elaborate fuel handling and storage equipment.

The success of any installation, of course, is in its use. The experience of those who have been tempted into this new field has, in general, been fortunate and favorable, and the success of the larger installations, both on this continent and in Europe, has been such as to justify the impression that the career of the electric boiler, so to speak, lies before it.

Hargreaves and The Spinning Jenny

By Justin McEachren,
Editor of *Valve World,* Chicago.

Lucretia with her distaff, and Marguerite and Priscilla at their spinning-wheels have served as themes for many a poem and painting. They have embodied, while thus engaged, the general conception of womanly industry; they have given us the Saxon word "wife"—a weaver—and they have gently wooed and won their Fausts and John Aldens while with deft fingers they spun yarn for homely wearing apparel or those fleecy knicknacks with which woman has been pleased to deck herself since long before Dorcas wrought with her maids.

But there is another picture that poets and painters seem to have overlooked, and yet which means more to the world than

all the fair spinning-dames of romance or history. It is a picture of a man standing by a spinning-wheel that he has overturned accidentally. In falling, the spindle has changed from a horizontal to a vertical position. Between the man's right thumb and first finger still runs the "roving" of fine cotton shreds. The spindle stops turning, and the man stands like a statue, gazing at the opposite wall, but seeing nothing there. He is lost in thought. Out of the fragments of his fancy he is engaged in weaving a fabric greater than any his yarns or crude threads have produced. Bit by bit he places in its proper position, here a wheel, there a spindle, till he sees his primitive spinning-wheel multiplied many times.

A Dream Takes Substance.

At last the fancy is complete; the dreamer awakes. James Hargreaves has invented the spinning-jenny and has begun one of the greatest cycles of invention the world has known. By that one stride he has made the year 1767 notable and has crowned himself with a laurel that all his after trials and the succeeding years have done nothing to wither. From this point dates the revolution in the cotton industry, which today employs thousands of workers in every part of the world and represents investments that reach far into the millions on millions of dollars.

James Hargreaves was of humble origin and his life was a succession of disappointments and persecutions. But he was industrious and a thinker. Seven years before he thought of the spinning-jenny he had invented the carding machine. The thought which impressed him when his spinning-wheel tipped over was, whether he could produce something to take the place of his thumb and finger in holding the "roving," and could arrange this contrivance to travel back and forth to and from vertical revolving spindles; if so, he might increase the number of spindles at pleasure. He made his first machine with eight spindles, and soon followed it with another having eighty spindles.

Vanquished by Lack of Vision.

Then the workmen of Lancashire, seeing in Hargreaves' invention, as they thought, the passing of hand-spinning and their means of livelihood, broke his machine and drove him out

of the locality. He died in Nottingham, unable to bear up againt this ill treatment,—died in obscurity and distress, a victim of his countrymen's ignorance, selfishness and lack of vision. But he left to the world his invention; and the Strutts, who took it up, laid thereon the foundation of their success and opulence.

The spinning jenny was by no means perfect as Hargreaves left it. While it produced a thread good enough for the weft in weaving, it could not be used for the warp. This fact appealed to Richard Arkwright, a Bolton barber and a general genius of sorts. In stropping his razors Arkwright had noticed a small, tight roll of oil and dust sometimes following the razor's edge as it was drawn quickly over the leather surface. Why could not a tightly-spun thread be produced in much the same way? he asked himself. Still pondering this problem, he one day watched the rolling of iron in a rolling-mill. He saw that the metal bar was lengthened by passing between sets of rollers, each set going faster than that preceding. He ådapted such a contrivance to Hargreaves' jenny, and the result was the "throstle machine," which produced a superior quality of thread or yarn.

Arkwright the Shrewd.

Arkwright, to avoid the riots that had ruined Hargreaves, announced that he was searching for perpetual motion, and thus he was left in peace to pursue his experiments. He formed a partnership with one of the Strutts, and they established a cotton-spinning mill, run by water power, at Cromford in Derbyshire. This factory was opened in 1771, and from it grew the immense factory system of England. Arkwright was not an inventor in the true sense. He was a clever adapter of the ideas of others and an intelligent observer. Perhaps that is why he escaped the trials of most great inventors, amassed a large fortune, and was honored by his sovereign with knighthood.

Demand for a still finer quality of cotton twist that would produce the fine muslins then imported from India, led to the next step in the development of the cotton industry. From working one of Hargreaves' machines and watching Arkwright's improvement upon it, Samuel Crompton was led to produce

his "mule," so called because it was a modification of both Hargreaves' and Arkwright's machines.

The "Mule" of Crompton.

Crompton lived at the picturesque Hall-in-the-Wood, near Bolton, far from the angry workpeople, who were riotously opposed to all improvements that threatened to supplant manual labor. Here he quietly prosecuted his investigations, and entirely with his own hands produced his first spinning "mule."

Carefully he guarded his secret, but the superior quality of yarn he was marketing led to its discovery, and Crompton saw the product of his brain and skill become public property, rapidly enriching others, but bringing nothing but a barren glory to its inventor. At last, when Crompton's mule was turning 4,600,000 spindles, spinning 40,000,000 pounds of cotton annually, and giving work directly to 230,000 persons in England, Parliament awarded him five thousand pounds, a mere bagatelle considering to what a point his skill had brought the cotton industry.

The power loom of Dr. Edmund Cartwright, invented in 1785, and the cotton gin of Eli Whitney, invented in 1793, rounded this circle of wonderful inventions applied to the working of cotton. Of the five inventors this country lays claim to Whitney. The other four were natives of England.

From Distaff to Jenny.

What a long stride it is from Lucretia to Priscilla. What a distance from the distaff to the handwheel, and how long the world was in covering it. Till the close of the eighteenth century men had been content to let women do the spinning and weaving, and most wondrous fabrics those fair fingers have wrought. Now the spinning-wheel is treasured as a relic or employed to deck the hall of some mansion as a reminder of a day long gone. But in many a pile of stone and mortar and steel, here, in England, in India, and other countries, millions of spindles are now drawing into threads of varying fineness the snow-white product of the southern fields, and hundreds of power looms are weaving fabrics for rich and poor, great and lowly, all giving employment to a vast army of workers,—simply because James Hargreaves tipped over his spinning-wheel, then fell a-dreaming. —*The Valve World.*

What Made Mammoth Cave?[1]

By B. Clifford Hendricks, University of Nebraska.

Anyone who has seen Mammoth Cave of Kentucky or The Cave of the Winds of Colorado, has wanted to ask such questions as: "How did it come to be?" "What giant gouged out those immense caverns?" "What fairy artist sculptured those columns?" "What decorator placed those pendant rock icicles from the ceiling, each with its mate reaching up to it from the floor?" One would hardly go to a chemist with such a question; yet, perhaps he may know more about it than would at first be thought. Let us try him and see. He will probably make his test tubes and solutions answer them, anyway.

1. *What did the digging and how was it done?*

To answer this question, he may first require that another be answered:

(1) What will dissolve limestone (calcium carbonate)?

In this test tube is a piece of limestone that might have been taken from Mammoth Cave. In this other test tube is some liquid that tastes sour, and turns this litmus paper red. Smell of it. It smells like vinegar, doesn't it? It is the *Acid* of *Vinegar*. When some of this "vinegar acid" is put upon the stone, notice what happens. It dissolves the stone and a gas comes off. We may say that "vingear acid" dissolves limestone.

(2) But what is the gas that comes off?

Let some of the gas from the stone be passed through this lime-water. Turns it milky, you see. The white stuff formed in the lime-water and making it milky is no other than limestone, or the same kind of material as this rock we started with. The chemist tells us that any gas that makes lime-water milky is *carbon dioxide*.

(3) What has that gas to do with the making of caves?

If much more of the carbon dioxide gas is forced

1 A group of seventh and eighth grade boys from the Lincoln city schools inspected the laboratories of the University of Nebraska a few years ago and the above article gives, in brief, a simple demonstration talk made by the author at the close of the inspection.

through the milky lime-water it clears up presently. The gas, carbon dioxide, and the water have dissolved the milkiness, i. e., the limestone. "Vinegar acid" dissolved it in the first experiment, and now this gas in water dissolves it. This gas in water acts like acid. Let's see if it affects litmus paper as did the "vinegar acid." Turns it pink, just as did the other acid. This carbon dioxide gas and water make an acid called carbonic acid. The carbonic acid dissolves limestone.

(4) Where does the water that "wears out" the caves get the carbonic acid?

Again our chemist refers us to his test tubes and solutions. He takes some lime-water in a test tube and bubbles some of his breath through it. It gets milky. That means that there is some carbon dioxide in his breath, doesn't it? If his breath contains carbon dioxide and your breath contains carbon dioxide, can you see where the rain gets its carbonic acid to dissolve the limestone? How then, may the caverns be formed?

(5) From what else may the water get carbon dioxide?

In this stoppered bottle are some partially decayed leaves that have been allowed to stand for several days. By changing to a two-holed rubber stopper, and by the aid of a bicycle pump and some tubing, the air from above these leaves is forced through the lime-water. Again a milky product results. Where did the carbon dioxide come from this time? If the rain should trickle through some decaying leaves at the earth's surface before it came to the limestone, would it then dissolve limestone any more readily than before?

Thus, in these five experiments, our chemist has answered our question as to "What did the digging and how was it done?" However, there still remains one of our original queries still unanswered.

2. *How were the rock icicles and columns made?*

Using some of the dissolved limestone from the carbon

dioxide solution, heat applied to the test tubes causes the milkiness to return. This milkiness, it was learned in a previous experiment, is limestone. If the test tube with it in were allowed to stand for a time the limestone powder would settle out. If, instead of the burner flame, the air were allowed to heat and evaporate the water from the limestone solution, would the result be any different? If some of this lime solution came through the roof of the cave and formed a drop upon the ceiling, then tumbled to the floor and of course splashed, what would be left at the ceiling and at the floor of the cave? If this dropping and splashing occurred day after day for many days, what would be the final result? This lime left day after day would increase, the lower column growing upward, and the upper coming down. Before they "grow together" the upper is called a *stalactite* and the lower is called a *stalagmite*. After the stalactite and stalagmite have "grown together" it is called a *column*.

So the chemist's test tubes and his solutions have told us how Mother Nature digs caves, supports them with pillars and ornaments them with fretwork. In fact, he can answer, by the aid of his test tubes and solutions, a surprisingly large number of questions which you and I may ask him. Some day we shall let him tell us how man can make stones that Mother Nature cannot so readily carve into caves.

The Teaching of General Science[1]

The history of the teaching of general science in this country has yet to be written. The chief points in the growth of the movement, so far as concerns the Association which is the parent of the School Science Review, may easily be recorded. In the last century, and during the first decade of the present one, science meant, for schoolboys generally, a drill in the more exact sciences. Chemistry, heat and light, for the most part, bounded their horizons. In a few schools only, where the education was less controlled by external examination and inspection, an efford was made to give a broader outlook.

1 From "The School Science Review," London, Sept., 1922.

Not until the end of 1915 and during the subsequent year were conditions favourable for the pioneers among the movement to make their voices heard effectively. Those years saw the birth of the Neglect of Science Committee and of the Prime Minister's Committee on Science in Education: the one, the result of popular clamour; the other, the official reaction. The ultimate origin of both was the committee room of what was then the Association of Public School Science Masters. At the same time, the Board of Education was co-ordinating the first school examinations, as they are now called. The Association at last had the opportunity of replying to the questions, "What sort of science should be taught to the rank and file?" To answer it, a somewhat vague—purposely vague—scheme called "Science for All" was published. In the light of new experience, a revision was printed in a recent number of this journal. The crystallized product is to be found in a schedule for the School Certificate Examination of the Oxford and Cambridge Joint Examining Board.

All the time, a similar movement has been going on in America. As in this country, it began by efforts made at two or three schools to take, in the words of the Principal of one of them, a bird's-eye instead of a toad's-eye view of science. As in this country, again progress has only been rapid during the past ten years or so. It is rather astonishing how little is known of what has been done in this direction across the Atlantic. The story of the teaching of general science in America, told by Professor Eikenberry, has, however, just been published at University of Chicago Press; and it will be a matter of reproach of anyone concerned in the movement here not to have read it.

The Americans are, in some respects, so different from ourselves. They are more conscious of their aim; more analytical in their thought; more systematic in their methods. And though these virtues are some times marred by the corresponding faults of self-consciousness and pedantry, it behoves us to know the good and shun the evil. It is the good which Professor Eikenberry describes in his book. He would be an exceptional teacher whose work was not improved after reading it.

"An Ounce of Prevention"

By Normal College Students, Truro, N. S.

Characters: Miss Sanitation
Cold-in-the-Head
Sore-Throat
Headache

Scene—Room with chair and table, several bottles on table.

Enter Miss Sanitation, dressed in spotless white.

Miss Sanitation—"Dear me! What a task it is to keep this world sanitary. There are so many germs, and people are *so* careless! The worst of it is, our enemy Influenza lurks around the corner, seeking whom he may devour."

Influenza peeps around the corner and growls. She is dressed in black and wears a black mask.

Enter Cold-in-the-Head. She may be dressed in ordinary school costume. She sneezes violently and appears to have no handkerchief.

Cold-in-the-Head—"Oh, Miss Sanitation, I have such a cold! It makes me feel sick, and I am so afraid! Influenza has been chasing me, and I came straight to you. What shall I do?" (Sniffs audibly.)

Miss Sanitation—"My child, where is your handkerchief?"

Cold-in-the-Head—"I have none."

Miss Sanitation—"You should always have a clean handkerchief. Take this one, and *use it.* Be sure to keep dry and warm, take some deep breathing exercises in the open air, and your cold will soon be well."

Influenza again peers in and growls.

Miss Sanitation—"Go away, Influenza! There is no place for you here."

Exit Cold-in-the-Head from opposite side of stage, holding her nose with the clean handkerchief.

Enter Sore-Throat. She keeps her hands on her throat and appears to be suffering greatly.

Sore-Throat—"Oh, my throat is so sore, I can hardly swal-

low!" (To prove this she swallows and make a horrible face.) "Influenza is following me, I am sure."

Influenza growls at the door.

Miss Sanitation—"Come here, my dear. Stick out your tongue." (She looks at child's throat.) "I am going to give you this to use as a gargle." (Pours some liquid from large bottle into a small one, and gives child.) "Now, if you use this and are careful not to take more cold, old Influenza will never get you."

Sore-Throat goes out one door, just as Influenza pops her head in at the other.

Enter Headache, holding her head with both hands.

Headache—"Please save me, dear Miss Sanitation! I have such a dreadful headache, and Influenza chased me right to the door! Do help me!"

Miss Sanitation (rubs child's head with alcohol)—"Now, dear child, take this." (Pours out liquid from bottle marked castor oil, gives it to Headache, who drinks it and makes a wry face.) "You had better go home and go to bed."

Influenza growls louder than ever as Headache runs off stage.

After a few moments, Cold-in-the-Head, Sore-Throat and Headache come back, join hands, and say in unison:

"An ounce of Prevention is Worth a Pound of Cure."

(Curtain)

—*Educational Review, Sept.* 1922.

Book Reviews

Heat and Energy—D. R. Pye—211 pages—59 illustrations—$1.70—Oxford University Press, American Branch, New York.

The author aims in this volume "to give a comprehensive conception of energy as the basis of all activity in nature and to make clear the essential unity of the different forms in which we recognize its existence; to illustrate its convertibility into forms suitable for storage, transference and use." The main topics are: Importance of heat—temperature—thermometers; measurements of heat—calorimeter—specific heats; nature and effects of heat—molecular motion—change of state; gases and vapors; latent heat; transference of heat; heat, work and energy; forms of energy; energy as light and sound; power production; domestic use of heat; mechanical production of heat. A fine reference book for the science student and instructor as well. It has real science treatment, but will, we believe, hold the interest of the boy scientist.

The Biology of Man and Other Organisms—Henry R. Linville—xii + 508 pages—238 illustrations—$1.68—Harcourt, Brace and Company, New York.

A list of chapter titles, starting off with, "the slipper and amalcule," "sponges," "jellyfish," "starfish," "insects and other near relatives," does not give one a very clear of this book. A few chapters from the middle, "our resources in clothing," "our bodies as we find them," "the source of our food supply," "care and preparation of food," tell better that it is a book pertaining to human welfare. The leading theme is human interest, but a complete view of living forms is given in a very interesting manner. A valuable chapter on biography is found in "builders of biology,"—and important facts are told in "things and conditions that hold us back." In addition to its new features it also covers the usual prescribed high school biology syllabus.

Chemistry Applied to Home and Community—Pauline G. Beery—534 pages—85 illustrations—J. B. Lippincott Company.

This book covers a field which, considering its importance, has been rather neglected. It assumes a previous knowledge of general inorganic chemistry. It aims to lay the foundation for courses in nutrition, cookery, industrial arts, textiles and housewifery, and to apply chemical knowledge to a woman's problems. It treats of fuels, fire, water, wastes, cleaning and polishing agents, textiles, dyes, paints, cellulose industries, silicate industries, toilet preparations, foods and drugs. Some knowledge of organic chemistry is desirable before undertaking this study, but the essentials of organic chemistry are given in a fifty-two page appendix. Laboratory experiments are included in the text. Topics for additional study are suggested and a valuable bibliography ends each chapter. We have not seen a book before that gives the housewife so much usable, practical information on subjects allied to chemistry as does this text. In spite of its being a college text, the general reader will find much of it interesting reading.

How We Are Clothed—James F. Chamberlain—189 pages—Fully illustrated—The Macmillan Company.

The story of our clothing is simply and interestingly told, in a manner to appeal to children. It ranks among the best geographical readers. The field covered is indicated by these titles: Northern neighbors, by the dikes, the far East, cotton fields, on a sheep ranch, woolen cloth, manufacture of clothing, a field of flax, work of the silkworms, leather, where the raincoat grows, furry friends, seals, a spool of thread, needles and pins, hats, a pair of gloves, buttons, laundry, dry cleaning, dyes and dyeing, gold, patinum, pearls.

Economic Geography of Indiana—Stephen S. Visher—225 pages—Map of Illinois and 105 illustrations—D. Appleton & Company.

This is a valuable contribution to geography. Not only does it serve to educate the people within Indiana, but so well does it set forth the advantages and achievements of Indiana that outsiders are filled with a desire to try it. The topics covered are:
advantages of location; topography, soil and forests; climate; transportation; agriculture; crops and farm animals; extractive industries and related maufactures; manufacturing industries; leading manufactures; chief cities; commerce; Indiana's richness.

How We Are Fed—James F. Chamberlain—200 pages—94 illustrations—The Macmillan Company.

This is the first of the revised geographical readers in the *Home and World Series*. Those foods have been chosen for consideration which best develop a knowledge of geographical conditions and of man's relation to man. The book is adapted for silent reading in the grades. Each chapter ends with a few questions which test a pupil on the subject covered. These subjects treated are: The past and the present, a loaf of bread, meat supply, market gardening, dairy products, fishing industry, oyster farming, rice, sugar, where salt comes from, macaroni, on a coffee plantation, tea gardens, a cup of cocoa, a cranberry bog, a bunch of bananas, dates, oranges, a visit to a vineyard, nuts, a strange conversation, dining away from home, a drink of water.

Elementary Science, Nature Study and Practical work—Committee of Science Masters' Association—20 pages—$.35—Oxford University Press, American Branch, N. Y. C.

While this bulletin gives us a suggestion of the Science Masters' views on introductory science it is far from satisfying. The main syllabus is on nature study arranged by seasons. Several specimen lessons are given.

Psychology For Students Of Education—Arthur I. Gates— 489 pages —63 cuts—The MacMillan Company.

The material for this book was elected to present important principles of psychology which have significant applications in education. There is much less of the experimental and descriptive study of sensory processes and perceptions than you find in the average text. Much attention is paid to the mechanics and dynamics of human nature. This is a very "readable" book and is filled with practical suggestions.

Introduction to Psychology—Carl E. Seashore—427 pages—44 illustrations—The MacMillan Company.

Action as well as thought is an objective of this book. Experiment is expected to take half the time of preparation. The challenge is given for first hand observations. The experiments outlined in nearly every chapter, the questions and suggestions, all stimulate thought and encourage the socialized recitation. Physiology is relegated to background, the chief aim apparently being to make psychology a real factor in real life.

Comparative Vertebrate Dissections—William H. Atwood—xi + 248 pages—58 illustrations—P. Blakiston's Son & Co.

Beginning with the simple amphioxus as a type vertebrate, the alligator, turtle, pigeon and cat. In most of these studies the work is organized under these headings: external features integument: author then takes up in order, the shark, perch, necturus, frog, snake, skeletal system, muscle system, digestion system, respiratory system, blood system, urogenital system, and the nervous system. Diagrams are given showing many things the student is to find. This verfication method is justified as a time saver. The directions included in this material have had successful use in teaching dental and premedical students.

How to Experiment in Education—William A. McCall—281 pages—The Macmillan Company.

The object of this book is twofold: a guide for those who desire to undertake experimental work in education, and to prepare one to understand the technical reports of experiments which are now becoming so common in educational literature. It treats the experimental problem method, subject, conditions, measurements; computations for the one-group experimental methods; for the equivalent-groups method, for rotational experimental method; casual investigations, and analysis of experimental and causal investigations.

General Science at Boston University

Boston University is now offering a course of fifteen lectures on Methods of Teaching General Science in High Schools. These are given under the personal direction of Prof. Lyman C. Newell. The lectures are as flolows:

1. The Place of General Science in the Curriculum of High Schools.—Dr. Payson Smith, Commissioner of Education of the State of Massachusetts.

2. The Problem Method of Teaching General Science.—Joseph R. Lunt, Teacher of General Science, High School of Commerce.

3. A Demonstration Lesson by the Problem Method.—Joseph R. Lunt.

4. Demonstration Work as a Part of the General Science Course.—Dr. Otis C. Caldwell, Director of the Lincoln School of Teachers College, Columbia University, New York.

5. "Behind the Scenes."—Assistant Professor Charles E. Stratton, Boston University.

6. The Boston University Plan of Teaching General Science in High Schools.—Professor Lyman C. Newell, Head of the Department of Chemistry and Lecturer on Methods of Science Teaching, Boston University.

7. A Demonstration Lesson by the Boston University Plan.—Miss Ruth F. Keyes, A.M., Teacher of General Science in the Everett (Mass.) High School.

8. The Teaching of General Science in Junior High Schools.—Walter G. Whitman, Salem (Mass.) Normal School.

9. A Typical Demonstration Exercise in General Science.—Assistant Professor Charles E. Stratton.

10. Aids for Teachers of General Science.—Professor Lyman C. Newell.

11. How to Make the Best Use of the Biology Content of General Science.—Professor Samuel C. Prescott, Head of the Department of Biology in the Massachusetts Institute of Technology.

12. The Project Method of Teaching General Science.—Dr. Guy M. Wilson, Professor of Education, Boston University.

13. How to Make the Best Use of the Physics Content of General Science.—John C. Packard, Teacher of Physics in the Brookline (Mass.) High School.

14. How to Make the Best Use of the Chemistry Content of General Science.—Professor Lyman C. Newell.

15. Fundamental Qualifications of a Teacher of General Science.—Professor Lyman C. Newell.

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To launch our helium airship. Lit. Dig. 78:7:26. Aug. 18, 1923.

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The public conscience and accidents. Marcus A. Dow. Amer. City. 28:256-8. June, 1923.

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Uncle Sam's agricultural proving ground. Ill. Ralph Howard. Sci. Amer. 129:10. July, 1923.

Where corn is king. Ill. George H. Dacy. Sci. Amer. 129:22. July, 1923.

Making garden tools. Com'l. Amer. 19:12:43. June, 1923.

Women on the farm. George H. Dacy. Sci. Amer. 129:110 Aug., 1923.

ALCOHOLISM

Effect of prohibition on alcoholism. Lit. Dig. 78:2:20. July 14, 1923.

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The world's largest alligator ranch. Ill. George H. Dacy. Nature Mag. 2:1:9. June, 1923.

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Saving our big game animals. Ill. Guy E. Mitchell. Nature Mag. 1:2:13. Feb., 1923.

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The cosmic dust clouds of interstellar space. Ill. Isabelle M. Lewis. Sci. Inv. 10:11:75. Apr., 1923.

If our sun should become a Nova. Ill. Isabelle M. Lewis. Sci. and Inv. 11:17. May, 1923.

Venus—the planet of mystery. Ill. Isabelle A. Lewis. Sci. and Inv. 11:136. June, 1923.

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Equipment for automobile tourist's camp. A. J. R. Curtis and J. Tait. Pop. Mech. 40:129-134. July, 1923.

Building a camp car. Ill. Ray F. Kuns. Pop. Mech. 40:147-153. July, 1923.

AUTOMOBILE

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